Environmental Health

The Journal of the Australian Institute of Environmental Health

...linking the science and practice of Environmental Health

Environmental Health

The Journal of the Australian Institute of Environmental Health

ISSN 1444-5212

Environmental Health is a quarterly, international, peer-reviewed journal designed to publish articles on a range of issues influencing environmental health. The Journal aims to provide a link between the science and practice of environmental health, with a particular emphasis on Australia and the Asia-Pacific Region.

The Journal publishes articles on research and theory, policy reports and analyses, case studies of professional practice initiatives, changes in legislation and regulations and their implications, global influences in environmental health, and book reviews. Special Issues of Conference Proceedings or on themes of particular interest, and review articles will also be published.

The Journal recognises the diversity of issues addressed in the environmental health field, and seeks to provide a forum for scientists and practitioners from a range of disciplines. Environmental Health covers the interaction between the natural, built and social environment and human health, including ecosystem health and sustainable development, the identification, assessment and control of occupational hazards, communicable disease control and prevention, and the general risk assessment and management of environmental health hazards.

Aims

- To provide a link between the science and practice of environmental health, with a particular emphasis on Australia and the Asia-Pacific Region
- To promote the standing and visibility of environmental health
- To provide a forum for discussion and information exchange
- To support and inform critical discussion on environmental health in relation to Australia's diverse society
- To support and inform critical discussion on environmental health in relation to Australia's Aboriginal and Torres Strait Islander communities
- To promote quality improvement and best practice in all areas of environmental health
- To encourage contributions from students

Correspondence:
Jim Smith
Editor, Environmental Health
P O Box 225
Kew, Victoria, 3101
Australia

Telephone: 61 3 9855 2444
Fax: 61 3 9855 2442
Email: jim@infocusmg.com.au
Website: www.aieh.org.au

Environmental Health

The Journal of the Australian Institute of Environmental Health

ABN 58 000 031 998

ISSN 1444-5212 (Print), ISSN 1832-3367 (Online)

...linking the science and practice of environmental health

The Australian Institute of Environmental Health gratefully acknowledges the financial assistance and support provided by the Commonwealth Department of Health and Aged Care in relation to the publication of Environmental Health. However, the opinions expressed in this Journal are those of the authors and do not necessarily represent the views of the Commonwealth.

All opinions expressed in the journal are those of the authors. The Editor, Advisory Board, Editorial Committee and the publishers do not hold themselves responsible for statements by contributors.

Published by Environmental Health, The Journal of the Australian Institute of Environmental Health.

Correspondence to: Jim Smith, Editor, P O Box 225 Kew, Victoria, 3101, Australia.

Cover Design by: Motiv Design, Stepney, South Australia

Design & typeset by: Mac-Nificent, Northcote, Victoria

Environmental Health © 2007

ISSN 1444-5212 (Print), ISSN 1832-3367 (Online)

Call for Papers

The Journal is seeking papers for publication.

Environmental Health is a quarterly, international, peer-reviewed journal designed to publish articles on a range of issues influencing environmental health. The Journal aims to provide a link between the science and practice of environmental health, with a particular emphasis on Australia and the Asia-Pacific Region.

The Journal publishes articles on research and theory, policy reports and analyses, case studies of professional practice initiatives, changes in legislation and regulations and their implications, global influences in environmental health, and book reviews. Special Issues of Conference Proceedings or on themes of particular interest, and review articles will also be published.

The Journal recognises the diversity of issues addressed in the environmental health field, and seeks to provide a forum for scientists and practitioners from a range of disciplines. Environmental Health covers the interaction between the natural, built and social environment and human health, including ecosystem health and sustainable development, the identification, assessment and control of occupational hazards, communicable disease control and prevention, and the general risk assessment and management of environmental health hazards.

Aims

- To provide a link between the science and practice of environmental health, with a particular emphasis on Australia and the Asia-Pacific Region
- To promote the standing and visibility of environmental health
- To provide a forum for discussion and information exchange
- To support and inform critical discussion on environmental health in relation to Australia's diverse society
- To support and inform critical discussion on environmental health in relation to Australia's Aboriginal and Torres Strait Islander communities
- To promote quality improvement and best practice in all areas of environmental health
- To encourage contributions from students

Papers can be published under any of the following content areas:

Guest Editorials

Guest Editorials address topics of current interest. These may include Reports on current research, policy or practice issues, or on Symposia or Conferences. Editorials should be approximately 700 words in length.

Research and Theory

Articles under Research and Theory should be 3000-5000 words in length and can include either quantitative or qualitative research and theoretical articles. Up to six key words should be included. Name/s and affiliation/s of author/s to be included at start of paper and contact details including email address at the end.

Practice, Policy and Law

Articles and reports should be approximately 3000 words in length and can include articles and reports on successful practice interventions, discussion of practice initiatives and applications, and case studies; changes in policy, analyses, and implications; changes in laws and regulations and their implications, and global influences in environmental health. Up to six key words should be included. Name/s and affiliation/s of author/s should be included at start of paper and contact details including email address at the end.

Reports and Reviews

Short reports of topical interest should be approximately 1500 words. Book reviews should be approximately 700 words and Review Articles should not exceed 3000 words in length.

Correspondence

Associate Professor Heather Gardner
Editor, Environmental Health
PO Box 68, Kangaroo Ground, Victoria, 3097
AUSTRALIA
Guidelines for Authors can be obtained from the Editor
Telephone: 61 3 9712 0550
Fax: 61 3 9712 0511
Mobile: 0417 580 507
Email: gardner@minerva.com.au

In this issue of *Environmental Health* we explore many different topics, from water quality and wastewater treatments, to noise pollution and occupational exposures in a mine. For those involved in environmental health education, Talbot et al. present information on the use of environmental health literacies while Parissi looks at public participation in local government sustainability projects.

Rizak and Hrudey present evidence of water quality monitoring limitations for outbreak detection. They use examples of waterborne disease outbreaks to highlight the limitations of relying on treated drinking water quality monitoring to assure safe drinking water. The authors call for a greater understanding of these limitations by all persons involved in the analysis and interpretation of monitoring data and the design of monitoring programs. Outcomes of improved understanding include effectively planned programs, enhanced decision making and ultimately a greater assurance of drinking water safety and public health protection.

Also in Research and Theory, Wing and Oozthuizen conducted a survey of respiratory hazards and occupational exposures at a remote Australian mine to provide a detailed understanding of the level of health risks posed to production operators at the mine site. Workers were exposed to several contaminants, such as cobalt or nickel, which all have the potential to impact on the respiratory system. Control strategies were recommended and based on the exposure levels, and an appropriate and effective routine surveillance protocol was developed for the mine, with improved logsheets developed in consultation with miners. There is now an opportunity to expand upon this work and include contractors, and those involved in maintenance activities in future hazard identification and monitoring programs. Armed with this information, management can now accurately and confidently direct resources at exposure controls.

Talbot et al. explore how environmental health literacies can be used to guide curriculum development, assist accreditation and enhance quality assurance in university environmental health education. The authors describe a case study from the Bachelor of Public Health (Environmental Health) provided at the Bendigo campus of La Trobe University, Victoria, to describe how environmental health literacies have assisted the process of curriculum development, accreditation, and ongoing quality activities. The roles and benefits of literacies and curriculum-literacy maps are discussed with recommendations for other academic departments to use literacies to assist accreditation and QA activities.

Noise pollution is addressed by McLaren by reviewing noise provisions and at-risk children in New Zealand (NZ) early childhood centres. Noise in early childhood centres has been identified as a major concern in the initial consultation process as part of a complete revision of the NZ legislation. The advantages and limitations of two legal frameworks are discussed by McLaren in relation to the specific needs of children; the 'Setting of Prescribed Sound Pressure Level Limits' and the 'All Practicable Steps' model. The Standard for Construction Noise is also identified as an area for improvement when working near early childhood centres, especially regarding the effects of noise on at-risk children. McLaren recommends that early childhood centres play a more active role in the consultation process when noisy activities are proposed which may affect their children.

Parissi looks at public participation in local government by exploring a case study of regional sustainability monitoring in Western Sydney. Parissi explores this topic by examining the case study in context of the development of an alternative model in the preparation of the *Western Sydney Regional State of the Environment Report 2000*, and an exploration of the Report's problematic aftermath. Deeper public participation in the sustainability project within a local council framework is proposed.

Sekaran, Rajagopal and Pandian's paper investigates a cost-effective activated sludge process (CASP) used for removal of biodegradable contaminants in wastewater. In this system, Effective Microorganisms (EM) play a vital role in digesting the organic matter present in the wastewater. Sekaran et al.'s experiment revealed positive results for the CASP including good settling character, twice that of conventional activated sludge. The reduction was possible through quicker digestion, earlier completion of treatment leading to reduction in aeration time, eliminating thickener (secondary settling tanks) thereby reducing the construction and operation cost considerably.

There are two excellent reviews on highly relevant books by Thomas Tenkate.

Jim Smith
Editor

Back to TOC

Evidence of Water Quality Monitoring Limitations for Outbreak Detection

Samantha Rizak[1] and Steve E. Hrudey[2]

[1]Department of Epidemiology & Preventive Medicine & Cooperative Research Centre for Water Quality and Treatment, Monash University, Melbourne, & [2]Environmental Health Sciences, School of Public Health, University of Alberta, Canada

Monitoring treated drinking water quality as evidence of aapparent compliance with numerical guideline limits and standards is the rationale that currently underlies many drinking water regulatory programs. While it might seem logical to direct monitoring efforts to checking water after it is treated, experiences from waterborne disease outbreaks highlight that reliance on treated drinking water quality monitoring for assuring safe drinking water suffers from significant limitations. These include inadequate comprehensiveness of sampling (scope, volume and frequency), shortcomings in analytical methods and inadequate timeliness (inherent delays in reporting), the uncertain relevance of many parameters, and the inherent statistical limitations of monitoring for infrequent contamination. The limitations and capabilities of this monitoring, particularly with respect to public health protection, must be recognised and fully understood by all those involved in the analysis and interpretation of monitoring data, and the design of monitoring programs, so that monitoring strategies and programs can be more effectively planned to provide greater assurance of drinking water safety and public health protection.

Key words: Drinking Water Safety; Outbreaks; Water Quality Monitoring

Monitoring treated drinking water quality in the storage and distribution system (compliance or verification monitoring) has become the primary mechanism for managing and controlling drinking water quality and public health risks, both within Australia and in general around the world (Allen, Clancy & Rice 2000). At considerable expense, the water industry conducts extensive monitoring of treated water for microbial contaminants and a wide variety of chemical contaminants, ostensibly for the protection of public health. However, evidence from numerous waterborne disease outbreaks that have occurred in the developed world illustrate the failure of treated drinking water quality monitoring to prevent some outbreaks.

While there might be the impression that monitoring treated drinking water quality to provide evidence of apparent compliance with numerical guideline limits and standards assures safe drinking water, the inherent limitations make this approach by itself, an inadequate strategy for public health protection. These limitations include the shortcomings in analytical methods, the difficulties arising in interpreting the meaning of monitoring results, as well as the inherent quantitative limitations of monitoring for rare contamination episodes.

Analytical Difficulties and Timeliness of Monitoring Data

In addition to more recognised sampling limitations, the reliability and timeliness of analytical methods are also important limitations of relying on treated drinking water quality monitoring for assuring drinking water safety. First, no analytical method for water contaminants is 100% perfect. Although the uncertainty of analytical methods is generally not explicitly known, all water quality tests will have some false positive and false negative rates associated with them. Therefore, any samples with a true hazard present will sometimes report negative and samples without a true hazard will sometimes report positive. When dealing with water quality contaminants that occur infrequently, the effects of these imperfect methods can be quite dramatic as discussed below.

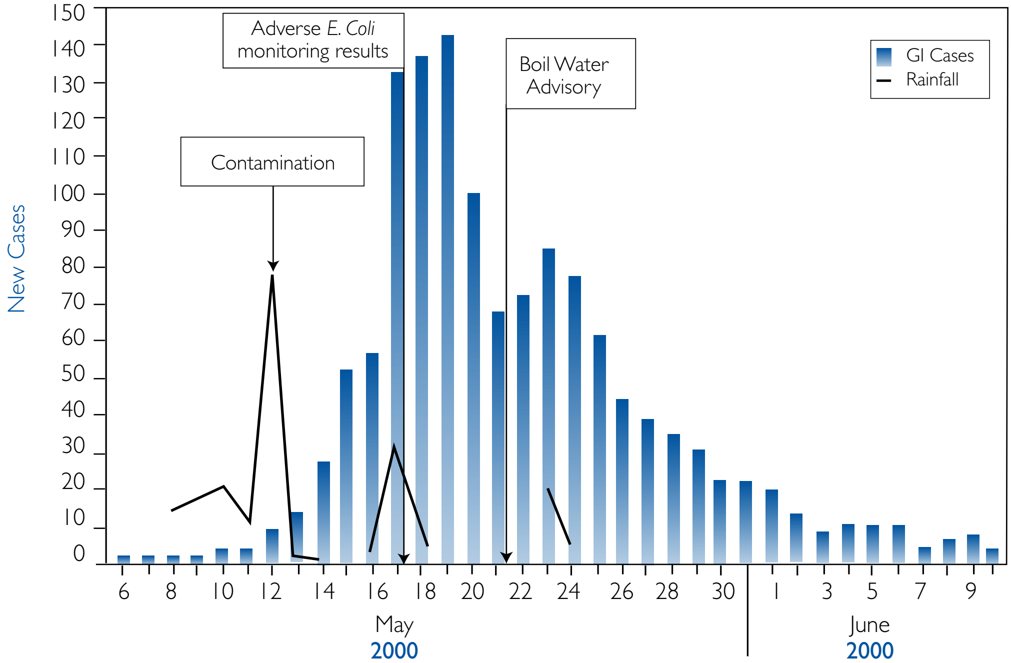
Particularly problematic analytical methods are those for specific pathogens such as *Cryptosporidium* and *Giardia*. These methods are not only expensive and time-consuming but they are also technically difficult and inherently unreliable (Allen, Clancy & Rice 2000). Major sources of error in these methods are misidentification (contributing to false positives) and incomplete recoveries (contributing to false negatives). Currently established methods also provide limited information on viability and no information on human infectivity (Wallis et al. 2001). Current risk assessment models also suggest that impractically large volumes of water would need to be tested to provide meaningful indications of health risk (Haas et al. 1996). It is for these reasons that monitoring treated drinking water quality for specific pathogens is typically not recommended (National Health and Medical Research Council [NHMRC] 2004).

Perhaps the most significant limitation in the ability of treated drinking water quality monitoring to predict or prevent waterborne disease outbreaks is the inadequate timeliness of analytical methods for reporting. For the vast majority of parameters, reliable results are only available a substantial time (in many cases, days) after a sample is taken. Thus if adverse monitoring results indicate potential contamination, depending on the water system and amount of treated water storage available, some customers are likely to have already consumed contaminated water before results are even received from the laboratory.

In fact, treated drinking water quality monitoring has often not proven useful as a warning when waterborne disease outbreaks have occurred. There are several examples that highlight the inherently reactive nature of this monitoring as a primary means for preventing outbreaks. Available outbreak curves from recent waterborne disease outbreaks are useful for illustrating this point. One such example is the waterborne disease outbreak at Walkerton, Canada in May 2000 that caused seven deaths along with over 2300 cases of gastroenteritis mainly from the pathogens *Escherichia coli* O157:H7 and *Campylobacter jejuni* (O'Connor 2002). Figure 1 presents the outbreak curve for this outbreak overlaid with the chronology of events.

Although an oversimplification of all factors that contributed to this outbreak, this figure is a useful illustration of the reactive nature of the monitoring data that were collected. The contamination was believed to have occurred on 12 May following a period of exceptionally heavy spring rainfall that produced flooding in the Walkerton area and contaminated the groundwater supply with cattle manure from a local farm. Three days later, microbiological monitoring of treated water quality in the distribution system was conducted. Gastrointestinal illness began appearing in the health care system on 18 May and there was growing absenteeism in Walkerton schools. Public health authorities were alerted on 19 May and an outbreak investigation was initiated. On 17 May, five days after the contamination entered the system, returned microbiological results revealed severe contamination of total coliforms and *E. coli*. Unfortunately, even this belated warning was not acted upon or conveyed to the local health authorities, who eventually called a 'boil water' advisory on 21 May when illness was already widespread in the community about

Figure 1: Chronology of events and gastrointestinal disease cases in the Walkerton outbreak



Based on data from Bruce-Grey-Owen Sound Health Unit (BGOSHU) 2000

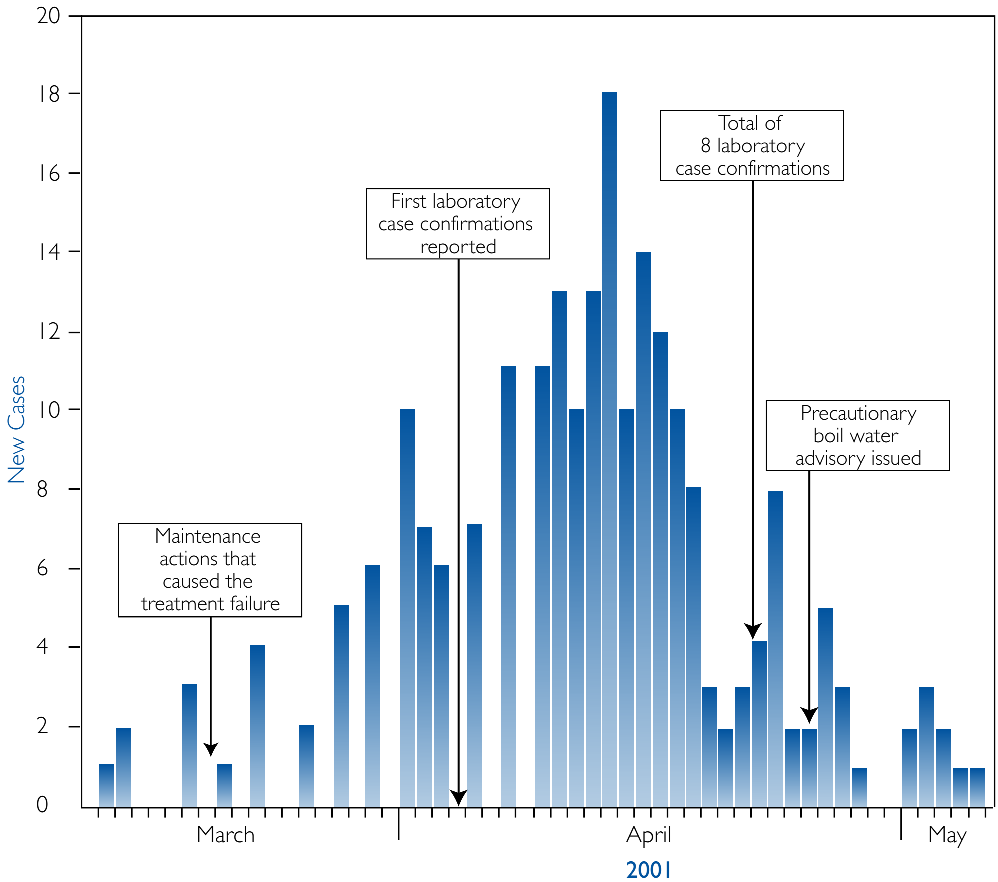
nine days after the contamination occurred (Hrudey & Hrudey 2004; O'Connor 2002). Another example is the outbreak of gastroenteritis in Freuchie, Scotland in March 1995 that affected an estimated 633 people of a population of approximately 1100. Contamination of the drinking water with *Escherichia coli* O157:H7 and *Campylobacter* occurred following an industrial cross connection and backflow of contaminated water drawn from a stream into the mains water of the village (FRC, FHB & NEFDC 1995; Jones & Roworth 1996).

The outbreak became apparent soon after consumer complaints of discolouration on 10 March, which immediately prompted flushing of mains, sampling and increased disinfection. Chemical analysis of water a few hours following sampling revealed the first signs of a potential problem when water quality characteristics were more typical of groundwater suggesting potential cross-connection with the mains water. Investigations uncovered that a local vegetable processing plant had been pumping water from a stream under the influence of groundwater as well as supplementing with mains water since 6 March because the private borehole, the company's normal supply, was out of use for maintenance. The stream from which it was pumping was below a treated sewage outfall. A preliminary 'boil water' advisory was promptly issued to the village after which it became apparent that several villagers had already been ill for three or four days. The following day several more people were identified with illness and microbiological results from the previous day's sampling indicated serious contamination of distributed water by faecal bacteria. By 13 March, an estimated 500 people had been affected with contaminated water.

Under regulations, routine sampling for microbiological parameters for the regional zone including Freuchie was required 26 times a year; the sampling program is based on randomly selected properties in randomly selected towns in the region. All service reservoirs also required weekly sampling for microbiological parameters. For the sampling year 1995, routine monitoring had occurred 10 times within the regional zone. However, random sampling in Freuchie had not yet taken place until the time of the incident.

The *Cryptosporidium* outbreak in North Battleford, Canada in 2001 is another example of the difficulties in using water quality monitoring data for outbreak detection. This outbreak resulted in between 5800 and 7100 cases of illness when maintenance of the solids contact clarifier at the water treatment plant led to poor treatment performance (Laing 2002). Figure 2 illustrates the chronology of events and gastrointestinal disease cases in the North Battleford outbreak. The maintenance of the solids contact unit took place on 20 March 2001 with contamination from the vulnerable river water source probably entering the system shortly thereafter. Negligible turbidity removal occurred for several weeks following this maintenance; however, the treated water quality monitoring showed no evidence of exceeding regulatory requirements. Illness was apparent within the community from 21 March, but it was not until 4 April that the first confirmed case of cryptosporidiosis was detected. By mid-April, hundreds of cases of illness had been reported. Despite the widespread gastroenteritis that was occurring within the community, the outbreak was not recognised as waterborne until 25 April, five weeks from its onset, resulting in a precautionary 'boil water' advisory being

Figure 2: Chronology of events and gastrointestinal disease cases in the North Battleford outbreak



Note: Based on data from Stirling et al. 2001

Box 1: Outbreak surveillance in Milwaukee

The cryptosporidiosis outbreak in Milwaukee, Wisconsin in March-April 1993, with an estimated 400,000 people affected, was attributed to microbial contamination of its surface water supply following heavy runoff and poor treatment performance occurring at the Howard Avenue filtration plant, the treatment plant that supplied the southern half of the city (Fox & Lytle 1996). Outbreak awareness occurred early in April when reports began to emerge concerning gastrointestinal illness and extensive absenteeism among hospital employees, students and school teachers, shortages of enteric bacteria culture media at some hospital laboratories as well as shortages of anti-diarrhoeal medications at some pharmacies (Proctor, Blair & Davis 1998). Data on nursing home diarrhoea cases were instrumental in recognising the outbreak as waterborne and informing the outbreak response. In Milwaukee nursing home data were available from 16 nursing homes, seven of which were served by the Howard Avenue treatment plant. Stool samples collected from 69 residents of southern nursing homes had 51% positive for Cryptosporidium compared with zero positive among 12 residents with diarrhoea from northern nursing homes (Addiss et al. 1994). This evidence combined with dramatic spikes in treated water turbidity at the treatment plant during the previous week in comparison with the northern plant implicated the south plant as the cause of the emerging outbreak, justifying a 'boil water' advisory being issued and a temporary shutdown of the southern plant (Proctor, Blair & Davis 1998).

issued (Hrudey & Hrudey 2004, pp. 316-340; Laing 2002).

In general, as these examples and many others demonstrate, current sampling protocols that focus on monitoring the treated drinking water quality in the distribution system are likely to miss the opportunity to be preventive and identify contamination episodes as they are occurring (Hrudey & Hrudey 2004). The pattern of monitoring results or confirmation of illness lagging behind a contamination episode is common to most waterborne disease outbreaks. For most systems, monitoring treated drinking water is too infrequent and limited to be adequate to detect or prevent contamination, particularly when it is intermittent and short-lived. In fact, rather than by means of any routine monitoring efforts, waterborne disease outbreaks almost invariably become known after the fact only when epidemiologic disease surveillance is able to detect substantial increases in cases of gastrointestinal illness or by other means such as hospital admissions, diarrhoea in nursing homes, increased sales of anti-diarrhoeal medication or increasing absenteeism in schools and workplaces (Box 1).

Further, reactive approaches such as this are limited to measures such as issuing 'boil water' advisories which are often not issued quickly enough to prevent community illness, with many examples where the advisory was issued late in the outbreak or when the outbreak was effectively over (Hrudey & Hrudey 2004). Even the effectiveness of compliance with boil water advisories for eliminating hazardous exposure has been shown to be limited (Angulo et al. 1997; Bruce-Grey-Owen Sound Health Unit [BGOSHU] 2000; O'Donnell, Platt & Aston 2000; Willocks et al. 2000).

Interpretation Challenges

There are also many difficulties arising in the interpretation of monitoring results for guiding risk management decisions, even beyond the shortcomings of sampling and analytical methods. First, water quality parameters are presumed to offer useful insights about health-related water quality but in reality there remain substantial limitations in our knowledge of the relationships between these parameters and their public health outcomes. For many parameters, there is difficulty in setting numerical guideline limits because of the uncertainty with potential health risk.

For microbial pathogens, while there is little uncertainty concerning causation of disease or illness via drinking water, there are many questions on the infectivity of pathogens and the infective dose required to produce illness (Goldstein et al. 1996). Different pathogens vary in their infectivity to humans and humans differ in their response to pathogens and there is often no clear association between pathogen levels in drinking water and human illness (Dupont et al. 1995; Gale & Stanfield 2000).

For chemical contaminants in drinking water, the issue of causation of disease has much greater uncertainties. Whereas the risk from pathogens in drinking water is clear and proven, relationships between chemicals, particularly at the low doses typically found in drinking water, and their health outcomes are much more uncertain and tenuous. Although the setting of exact numerical guideline limits for chemicals might convey a sense of confidence in their meaning, there are enormous uncertainties in the derivation of these values (Box 2). In fact, most health-related guideline limits are derived with more inference and judgement than direct evidence (Hrudey 2001). Waterborne disease outbreaks caused by chemical contamination are not as readily identifiable, nor as well documented, as from microbial pathogens. However, Craun and Calderon (2001) reported 35 chemical outbreaks in the United States community water systems between 1971 and 1998 arising from distribution system deficiencies. Such incidents invariably bring interpretation of chemical water quality guidelines into focus.

Overall, the implications of a positive test result are not often well understood and might not be helpful when risk-based public health decisions must be made on these data. Further, indicator parameters that are convenient to analyse are typically used as surrogate markers for pathogens and chemical contaminants that might cause health effects. For microbiological analyses, bacterial indicator organisms such as *E. coli* and thermotolerant coliforms (and previously total coliforms) are used as surrogates for the presence of faecal contamination and pathogenic organisms. Trihalomethanes are commonly used as surrogates for other potential disinfection by-products that might cause health effects. However, relationships between indicators and contaminants can also be tenuous. For instance, bacterial indicators have been shown to correlate well with bacterial pathogens but not necessarily with viruses and protozoa, which are more resistant to chlorination (Craun et al. 2002).

Box 2: Derivation of drinking water guideline levels

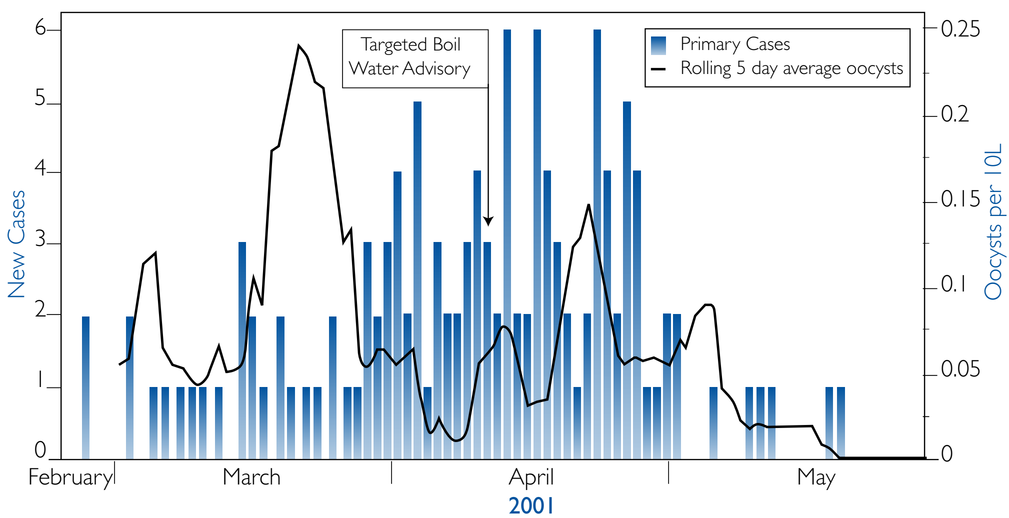
Drinking water guideline levels are based on environmental health risk assessments ideally determined through human epidemiologic data but more often through animal toxicology experiments. From these studies a dose is derived that corresponds to some policy-defined level of caution. A consistent drinking water exposure scenario is assumed to translate the dose per unit body mass for the contaminant into a drinking water concentration, which then becomes a numerical guideline value for that contaminant (Payment & Hrudey 2004). There are great uncertainties in this practice, particularly in deriving the dose level. For chemicals that are non-carcinogenic, the dose is based on dividing a 'no observable adverse effect level' (NOAEL) by some uncertainty factors to account for variations in extrapolating between species (animals to humans), variations between individuals, adequacy of studies or database, and nature and severity of effect. Uncertainty factors can range from 1 to 10,000 and are selected based on expert judgement and available scientific evidence. For chemicals that are, or potentially, carcinogenic there is even greater uncertainty in derivation of numerical guideline levels. Here, the relevant dose is extrapolated from high dose animal experiments (near the maximum of what the animal can tolerate) using a conservative, linear, no threshold model to estimate a dose at the very low dose levels you would expect to find in drinking water. This is a model based on a regulatory policy decision rather than on any scientific imperative (Payment & Hrudey 2004).

Thus even when drinking water quality criteria are met, pathogen contamination and outbreaks can still occur. This was evidenced by the outbreaks in North Battleford and Milwaukee. In both cases, sufficient chlorination was maintained to kill effectively bacterial pathogens. *Cryptosporidium*, however, requires effective turbidity removal, which was seriously deficient in both locations during the outbreak periods. Thus the absence of bacterial indicators such as *E. coli* does not necessarily mean the water is free from contamination.

However, even when direct measurement of pathogens has been used, interpretation and understanding the significance of results can still prove difficult. The viability of cysts and oocysts in treated water and the level at which they are observed to cause illness in humans are uncertain. An example of these difficulties occurred with the Sydney Water incidents in 1998 in which high levels of *Giardia* cysts and *Cryptosporidium* oocysts were detected in treated drinking water samples on repeated occasions throughout the distribution system (McClellan 1998). On the basis of these monitoring results, a series of 'boil water' advisories were issued and withdrawn over a period of three months. However, neither any increase in overall rates of gastrointestinal illness in the community nor any increase in *Cryptosporidium* infections was found despite enhanced surveillance by the health department.

Similarly, treated water monitoring in Edmonton, Canada during 1997 revealed breakthroughs of *Giardia* and *Cryptosporidium* following severe spring runoff and heavy summer rains (Gammie, Goatcher & Fok 1998). Previous years monitoring consistently indicated treated water levels usually less than 1 cyst/oocyst per 1000 litres. Investigations indicated that treatment performance was optimised and achieving the necessary log removal or better; however, some cysts/oocysts passed through the treatment process due to the extremely high source water levels challenging the system. At peak levels, the health authority issued 'boil water' advisories only to the immunocompromised because of their increased risk and susceptibility. Disease surveillance, however, observed no increase in the number of cases of disease for Edmonton throughout 1997.

Figure 3: Combined primary cases of laboratory-confirmed cryptosporidiosis in relation to rolling 5 day average continuous oocyst monitoring of treated water - Belfast.



Note: all oocyst numbers are less than 1 per 10L (Based on data from Smyth & Outbreak Control Team [OCT] 2002)

Alternatively, however, was the continuous sampling data for *Cryptosporidium* oocysts that were collected in Belfast, Northern Ireland during an outbreak in 2001. Monitoring data were collected for treated water consistent with regulations introduced by the Drinking Water Inspectorate (DWI) for England and Wales which established a regulatory standard of 1 oocyst per 10L. Any water companies judged to be at risk of *Cryptosporidium* contamination were required either to introduce effective fine particle removal processes (e.g. membrane filtration) or to undertake continuous monitoring of oocysts at a sampling rate of 40L/h (Waite & Jiggins 2003). The data shown in Figure 3 were obtained by this monitoring scheme during an extended outbreak of cryptosporidiosis involving at least 191 laboratory-confirmed cases, which was eventually tracked to one of Belfast's drinking water plants. The evidence of the outbreak was provided by epidemiology, signs of sewage contamination of the treated water at the plant site, and finding *Cryptosporidium* contamination of sewage in the onsite septic system. These treated water quality monitoring data, however, never exceeded the regulatory standard of 1 oocyst per 10L, a standard thought to preclude the possibility of outbreaks. The reasons for this discrepancy were not clear, but they ranged across various explanations from inefficient sampling, to the presence of a particularly virulent strain of *Cryptosporidium*, to further contamination occurring downstream of the sampling location (Hrudey & Hrudey 2004).

Fundamental Limitations of Monitoring for Rare Hazards

There are also some important quantitative limitations that are unavoidable and need to be considered in relation to any monitoring program that screens for rare contamination episodes. This is particularly true when monitoring treated drinking water quality whereby, providing that the water supply system is well-operated and managed, contamination episodes should be rare.

While it seems logical to direct monitoring towards checking water after it is treated, it turns out that such monitoring is much less likely to be accurate and informative for assuring safety than monitoring upstream (that is, before treatment) where contamination will be more prevalent. Monitoring source water to understand the contamination challenges and the variability of source water quality, combined with continuous treatment performance monitoring (e.g. turbidity, fine particle count and/or chlorine residual) to assure that treatment processes are functioning as designed, can provide better assurance of safety. The reason, which is well documented in the field of medical diagnostic screening, is that any monitoring method is far more likely to report false positive results than true positive results when it is applied to samples that are likely to contain very few positive contaminant detections, which is what should be expected for effectively treated drinking water. This anomaly arises because it is the frequency of the hazard being monitored for that is the primary driver determining the ability to detect contamination correctly (Hrudey & Rizak 2004).

Essentially, when interpreting the meaning of monitoring evidence, the probability that a positive test result is correct is termed the positive predictive value *(PPV)* of the test. The *PPV* is the probability that a hazard is truly present in a sample given one has been identified by a positive test. A reality recognised in the medical sciences is that the prevalence, or frequency, of that which is being tested for has a dramatic effect on predictive value, and is the dominant factor in determining the ability to interpret monitoring data and to identify correctly potential hazards. In practical terms, this means that for hazards that are rare or low frequency, the *PPV*, that is, our ability to correctly predict a true hazard with a single source of testing evidence, inevitably will be poor regardless of the capabilities of the analytical method currently available. In such circumstances, false positive results will greatly exceed the rare true positive results; and the rarer the occurrence of the hazard the smaller is the *PPV* (Hrudey & Rizak 2004).

Thus as improvements are realised through better risk management practices making the occurrence of hazards in finished water more rare, the information value of monitoring the higher quality water declines. Many more false positives than true positives are generated as monitoring is applied to rare hazards. This reality places a large onus on good judgement and appropriate response when interpreting positive monitoring evidence in these cases (Rizak & Hrudey 2006). Both the interpretation of monitoring data and the effective design of monitoring programs for assuring drinking water safety demand a clear understanding of these relationships governing the nature of monitoring evidence. Our research indicates that many water professionals and other environmental professionals do not appreciate this fundamental reality about water quality monitoring data (Jalba, Rizak & Hrudey 2005; Rizak & Hrudey 2006).

Conclusion

Evidence from waterborne disease outbreaks that have occurred in the developed world highlight that reliance on treated drinking water quality monitoring alone for assuring safe drinking water suffers from several significant limitations. In addition to sampling limitations, these include shortcomings in analytical methods and inadequate timeliness (inherent delays in reporting), the uncertain relevance of many parameters, and the inherent statistical limitations of monitoring for rare contamination.

While it may seem logical to direct monitoring efforts to checking water after it is treated, this monitoring, in itself, is not sufficient to guarantee the safety of drinking water. As experiences with waterborne disease outbreaks illustrate, contamination of drinking water in the developed world is characteristically intermittent, short-lived and often event-driven. Thus unless contamination is widespread and ongoing, current sampling protocols that emphasise monitoring treated drinking water quality will likely fail to detect contamination episodes as they are occurring and miss the opportunity to be preventive. Given these practical realities, the safety of drinking water needs to be assessed and assured by maintaining and continually improving the quality of extraction, treatment and distribution operation performance of the water provider; that is, good practice rather than treated drinking water quality monitoring provides the primary protection for consumers. These perspectives have now been formally recognised by leading international water quality organisations in the Bonn Charter for Safe Drinking Water, under the auspices of the International Water Association (IWA 2004).

With a combination of effective source water and operational monitoring, monitoring treated drinking water quality does provide, however, final verification that preventive measures are working effectively to ensure drinking water safety. Certainly, this information serves to ascertain long-term system performance, satisfy external requirements of compliance, identify trends and areas requiring improvement, and provide assurance for maintaining public confidence. However, the limitations of this monitoring, particularly with respect to public health protection, must be understood by all those involved in the analysis and interpretation of monitoring data. Monitoring strategies and programs can then be more effectively planned to enhance decision making and provide greater assurance of drinking water safety and public health protection.

Acknowledgments

Financial support from the Cooperative Research Centre for Water Quality and Treatment, the Canadian Water Network, Alberta Health and Wellness, and the Natural Sciences and Engineering Research Council of Canada are gratefully acknowledged.

References

Addiss, D.G., MacKenzie, W.R., Hoxie, N.J., Gradus, M.S., Blair, K.A., Proctor, K.E., Kazmierczak, J.J., Schell, W.L., Oscwe, P., Frisby, H., Cicerello, H., Cordell, R.L., Rose, J.B. & Davis, J.P. 1994, 'Epidemiologic features and implications of the Milwaukee *Cryptosporidium* outbreak.', *Protozoan Parasites and Water*, University of York, Royal Society of Chemistry, Cambridge.

Allen, M.J., Clancy, J.L. & Rice, E.W. 2000, 'The plain, hard truth about pathogen monitoring', *Journal of the American Water Works Association*, vol. 92, no. 9, pp. 64-76.

Angulo, F.J., Tippen, S., Sharp, D.J., Payne, B.J., Collier, C., Hill, J.E., Barrett, T.J., Clark, R.M., Geldreich, E.E., Donnell, H.D. & Swerdlow, D.L. 1997, 'A community waterborne outbreak of salmonellosis and the effectiveness of a boil water order', *American Journal of Public Health*, vol. 87, no. 4, pp. 580-4.

Bruce-Grey-Owen Sound Health Unit (BGOSHU) 2000, *The Investigative Report of the Walkerton Outbreak of Waterborne Gastroenteritis May-June 2000*, Owen Sound, Bruce-Grey-Owen Sound Health Unit, Ontario.

Craun, G.F. & Calderon, R.L. 2001, 'Waterborne disease outbreaks caused by distribution system deficiencies', *Journal of the American Water Works Association*, vol. 93, no. 9, pp. 64-75.

Craun, G.F., Nwachuku, N., Calderon, R.L. & Craun, M.F. 2002, 'Outbreaks in drinking-water systems, 1991-1998', *Journal of Environmental Health*, vol. 65, no. 1, pp. 16-23.

Dupont, H.L., Chappell, C.L., Sterling, C.R., Okhuysen, P.C., Rose, J.B. & Jakubowski, W. 1995, 'Infectivity of *Cryptosporidium parvum* in healthy volunteers', *New England Journal of Medicine*, vol. 332, pp. 855-9.

Fife Regional Council (FRC), Fife Health Board (FHB), & NorthEast Fife District Council (NEFDC) 1995, *Joint Report on the Contamination of the Public Water Supply to the Village of Freuchie, Fife March 1995*, Fife Regional Council, Fife Health Board, NorthEast Fife District Council, Fife, Scotland.

Fox, K.R. & Lytle, D.A. 1996, 'Milwaukee's crypto outbreak: Investigation and recommendations', *Journal of the American Water Works Association*, vol. 88, no. 9, pp. 87-94.

Gale, P. & Stanfield, G. 2000, '*Cryptosporidium* during a simulated outbreak', *Journal of the American Water Works Association*, vol. 92, no. 9, pp. 105-116.

Gammie, L., Goatcher, L. & Fok, N. 1998, A *Giardia/Cryptosporidium* near miss? *Eighth National Conference on Drinking Water*, Quebec City, Canadian Water and Wastewater Association, Ottawa.

Goldstein, S.T., Juranek, D.D., Ravenholt, O., Hightower, A.W., Martin, D.G., Mesnik, J.L., Griffiths, S.D., Bryant, A.J., Reich, R.R. & Herwaldt, B.L. 1996, 'Cryptosporidiosis: An outbreak associated with drinking water despite state-of-the-art water treatment', *Annals of Internal Medicine*, vol. 124, no. 5, pp. 459-68.

Haas, C.N., Crockett, C., Rose, J.B., Gerba, C.P. & Fazil, A. 1996, 'Risk assessment of Cryptosporidium parvum oocysts in drinking water', *Journal of the American Water Works Association*, vol. 88, no. 9, pp. 131-6.

Hrudey, S.E. 2001, 'Drinking water quality: a risk management approach', *Water*, January, pp. 29-32.

Hrudey, S.E. & Hrudey, E.J. 2004, *Safe Drinking Water: Lessons from Recent Outbreaks in Affluent Nations*, IWA Publishing, London.

Hrudey, S.E. & Rizak, S. 2004, 'Discussion of rapid analytical techniques for drinking water security investigations', *Journal of the American Water Works Association*, vol. 96, no. 9, pp. 110-3.

International Water Association (IWA) 2004, *The Bonn Charter for Safe Drinking Water*, International Water Association, London. <http://www.iwahq.org/templates/ld_templates/layout_633184.aspx?ObjectId=640178> 14 January 2006.

Jalba, D., Rizak, S. & Hrudey, S.E. 2005, 'Interpretation of drinking water monitoring data for environmental health professionals', *Environmental Health*, vol. 5, no. 3, pp. 40-9.

Jones, I.G. & Roworth, M. 1996, 'An outbreak of *Escherichia coli* O157 and campylobacteriosis associated with contamination of drinking water supply', *Public Health*, vol. 110, pp. 277-82.

Laing, R. D. 2002, *Report of the Commission of Inquiry into Matters Relating to the Safety of the Public Drinking Water in the City of North Battleford Saskatchewan*, Department of Justice, Government of Saskatchewan, 372 pp. <http://www.northbattlefordwaterinquiry.ca> 14 January 2006.

McClellan, P. 1998, *Sydney Water Inquiry*, New South Wales Premier's Department, Sydney, <http://www.premiers.nsw.gov.au/our_library/archives/sydwater/5threp/r5vol1.htm> 14 January 2006.

National Health and Medical Research Council (NHMRC) 2004, *Australian Drinking Water Guidelines*, National Health and Medical Research Council, Canberra, <http://www.nhmrc.gov.au/publications/synopses/eh19syn.htm> 14 January 2006.

O'Connor, D.R. 2002, *Report of the Walkerton Inquiry, Part 1. The Events of May 2000 and Related Issues*, The Walkerton Inquiry, Toronto, 504 pp. <http://www.attorneygeneral.jus.gov.on.ca/english/about/pubs/walkerton> 14 January 2006.

O'Donnell, M., Platt, C. & Aston, R. 2000, 'Effect of a boil water notice on behaviour in the management of a water contamination incident', *Communicable Disease and Public Health*, vol. 3, no. 1, pp. 56-9.

Payment, P. & Hrudey, S.E. 2004, 'Is drinking water quality management in Canada based on health risk?' *Proceedings of the 11th National Conference and 2nd Policy Forum on Drinking Water,* Calgary, Canada, 3-6 April.

Proctor, M.E., Blair, K.A. & Davis, J.P. 1998, 'Surveillance data for waterborne illness detection: An assessment following a massive waterborne outbreak of *Cryptosporidium* infection', *Epidemiology and Infection*, vol. 120, pp. 43-54.

Rizak, S. & Hrudey, S.E. 2006, 'Misinterpretation of drinking water quality monitoring data with implications for risk management', *Environmental Science and Technology*, vol. 40, no. 17, pp. 5244-50.

Smyth, B. & Outbreak Control Team (OCT) 2002, *The Report of the Outbreak Control Team of an outbreak of Cryptosporidiosis during February/April 2001*, Belfast, Communicable Disease Surveillance Center (NI), pp. 41.

Stirling, R., Aramini, J., Ellis, A., Lim, G., Meyers, R., Fleury, M. & Werker, D. 2001, 'Waterborne cyptosporidiosis outbreak, North Battleford, Saskatchewan, Spring 2001', *Canadian Communicable Disease Report*, vol. 27, no. 22 page range?.

Waite, M. & Jiggins, P. 2003, 'Cryptosporidium in England and Wales', *Drinking Water and Infectious Disease: Establishing the Links*, P.R. Hunter, M. Waite and E. Ronchi, Boca Raton, CRC Press and IWA Publishing, pp. 119-26.

Wallis, P.M., Matson, D., Jones, M. & Jamieson, J. 2001, 'Application of monitoring data for *Giardia* and *Cryptosporidium* to boil water advisories', *Risk Analysis*, vol. 21, no. 6, pp. 1077-85.

Willocks, L., Sufi, F., Wall, R., Seng, C. & Swan, A.V. 2000, 'Compliance with advice to boil drinking water during an outbreak of cryptosporidiosis', *Communicable Disease and Public Health*, vol. 3, no. 2, pp. 137-8.

Correspondence to:
Samantha Rizak
Department of Epidemiology & Preventive Medicine & Cooperative Research Centre for Water Quality and Treatment
Monash University, Central and Eastern Clinical School
Alfred Hospital
Commercial Road
Melbourne, Victoria 3004
AUSTRALIA
Email: Samantha.Rizak@med.monash.edu.au

Back to TOC

Exposure Assessment: A Case Study

Hayden Wing and Jacques Oosthuizen

Exercise, Biomedical and Health Sciences,
Edith Cowan University, Western Australia

A survey of respiratory hazards and occupational exposures was conducted at a remote Australian cobalt and nickel mine and ore refinery. Samples of respirable dust and inhalable dust were further analysed for nickel, cobalt and quartz content. Sulphur dioxide, hydrogen sulphide and a variety of vapours such as toluene were also monitored. Workers were divided prospectively into similar exposure groups for survey purposes. Most of the employees on site were exposed to several contaminants, all of which have the potential to impact upon the respiratory system, necessitating the calculation of the hazard index. Exposure standards were adjusted for a 12-hour shift. A number of similar exposure groups were identified where workers were exposed to elevated levels of cobalt and/or nickel. Control strategies were recommended and based upon the exposure levels. A routine surveillance protocol was developed in order to monitor and manage respiratory hazards at the facility.

Key words: *Mine Workers; Respiratory Hazards; Nickel; Cobalt*

Accurately assessing workplace exposures to airborne contaminants presents significant challenges to occupational hygienists (OH). Exposure levels can vary considerably from day to day. They can even differ from hour to hour and obtaining an accurate picture of the exposure situation requires a sufficient number of environmental measurements (Rappaport 1991). As a starting point, it is important that the OH should be familiar with operational conditions that are often dynamic leading to fluctuating exposure levels. Environmental sampling should be conducted in a considered manner according to a pre-planned sampling protocol. This reduces error and enhances credibility and scientific rigor. The OH has to consider the total work environment, not just one contaminant in isolation (National Occupational Health and Safety Commission 1994a).

In this study an Australian nickel and cobalt ore processing facility was evaluated and a comprehensive environmental assessment was conducted in order to develop a longer-term exposure monitoring strategy. This ensured not only legal compliance but also adequate information to guide the management of work related health issues at the location.

The aim of a baseline monitoring program is to collect sufficient data to make an informed decision on whether or not the environment is likely to cause any adverse health effects to exposed individuals and to plan for further routine monitoring of the environment. The survey, therefore, needs to specify how many samples are required, when samples should be taken, how long each sample should run for, who should be monitored and how accurate the results need to be. The survey needs to identify all employees who may be exposed at or above the action level and quantify the exposure of the employees so identified (Leidel et al. 1977).

Mean exposure to a substance is usually used to estimate long term, chronic health risks. This model assumes linear kinetics (that is, increasing concentrations lead to a proportional increase in health risks). Non-linear kinetics can, however, arise from changes in individual uptake or susceptibility with time, from synergistic or antagonistic effects related to concurrent exposures to other chemical or biological agents, from allergenic responses to sensitising agents and from cumulative exposures and damage associated with episodes of intense exposure. Acute toxins in which elevated exposure can cause immediate health effects are evaluated by assessing peak exposure rather than long term average exposure (Rappaport 1991).

Methods

Exposure groups

Workers were grouped together into three distinct operational areas dealing with:

1. the handling and preparation of the ore material;

2. the production of and storage of utilities and products necessary for refinery; and

3. the refinery.

Within each of the three areas, workers were further sub-divided into similar exposure groups (SEGs). Employees were allocated to exposure zones based on the similarity of tasks performed, exposure to the same range of airborne contaminants (including by-products and intermediates), similarity of environment, that is process equipment, exposure sources and ventilation arrangements (Guest et al. 1993). The groups were established prospectively (before the study commenced).

Sampling strategy

In order to remove sampling error related to fluctuating exposure levels, shifts and workers to be sampled were selected randomly. A computer program incorporating a random number generator was used to develop the sampling program. The process involved assigning numbers to each SEG - atmospheric contaminant combination and each possible working shift, and then using the random number generator to build up the sampling program. Initially, six samples per SEG were taken. A subsequent analysis of the results then determined whether additional monitoring was required.

Samples

Inhalable dust consists of all dust particles that are able to be drawn into the human respiratory system and these samples were collected in accordance with AS 3640-2004 – Workplace Atmospheres – Method for sampling and gravimetric determination of inhalable dust (AS 3640 - 2004).

Respirable dust comprises the fraction of dust small enough to lodge in the alveoli of the lung, these samples were collected in accordance with AS 2985-1987 – Workplace Atmospheres – Method for sampling and gravimetric determination of respirable dust (AS 2985 - 1987). This standard was updated in 2004; the update involved an adjustment in the sampling flow rates. These changes did not come into effect in the West Australian mining industry until the 1st July 2004, and the sampling outlined in this study was conducted in accordance with the now superseded standard. Exactly how the new flow rate will influence data is yet to be determined. However, when comparing current and future respirable dust results to historical data, this factor will need to be considered.

Organic Vapours were sampled in terms of AS 2986.1 - 2003 - Workplace Air Quality -Sampling and analysis of volatile organic compounds by solvent desorption/gas chromatography, Part 1: Pumped sampling method (AS 2986.1 - 2003). Samples were sent to a National Association of Testing Authorities (NATA) laboratory for further analysis to identify specific constituents such as nickel and cobalt.

Monitoring for sulphuric acid mist was conducted according to ASTM D 4856 - 99 Standard Test Method for the Determination of Sulfuric Acid Mist in the Workplace Atmosphere (American Society for Testing and Materials 1999). Sampling for hydrogen sulphide, sulphur dioxide and ammonia was conducted using calibrated direct reading gas detectors with data-logging capability.

Statistical Evaluation of Results

The aim of the sampling program was to estimate worker exposures using a sample. To do this, it was necessary to define the distribution of exposures and the statistical package IHSTAT (Mulhausen & Damiano 1998) was used for this purpose.

The distribution of data was classified as either lognormal or normal. The mean of the sample was used to estimate health risk associated with long-term chronic disease. The 95% upper confidence limit (UCL) of the mean was compared to the exposure standard. It can be inferred with 95% confidence that if the 95%UCL of the sample mean is below the exposure standard then the arithmetic mean exposure of the sampled population should also be below the exposure standard.

Standard deviation (SD), which represents the variability of each set of exposure data, is extremely useful in assessing whether or not the SEGs were established correctly. If the SD is too high, this is an indication that exposures are not as similar as first thought, and that reclassification might be required. It is generally recommended that the SD should be less than three if the group is to be classified as an SEG (European Committee for Standardization 1995, p. 23). The UK Health and Safety Executive has stated that "no individual's exposure should be less than half or greater than twice the group mean"(Health and Safety Executive 1989, p. 44).

The predicted percent above exposure standard was calculated to obtain information regarding compliance on a shift-to-shift basis. In cases where exposures for a SEG did not fit either a lognormal or normal distribution simple descriptive statistics were used to describe workplace exposure scenarios. Additional exposure information was obtained through the use of logbooks that were kept by the workers detailing their exact activities during the sampling period.

It has been suggested that when samples are determined to be below the level of detection, a factor of 0.7 times the detection limit should be used if the data have a geometric standard deviation less than 3, and a factor of 0.5 times the detection limit should be used if the data have a geometric standard deviation greater than three (Mulhausen & Damiano 1998 p. 129). Alternatively, a factor of 0.7 times the detection limit can be used if the data are lognormally distributed, and a factor of 0.5 if the data follow a normal distribution (Guest et al. 1993, p. 62).

Exposure to multiple atmospheric contaminants

At the study location workers are exposed to several contaminants all of which have the potential to create adverse health effects and therefore the possibility of additive effects had to be considered. In this study, the hazard index was calculated by adding the ratios of each exposure to the exposure standard as follows:

C1/ES1 + C2/ES2 +... Cn/ES1; (C = Concentration and ES = Exposure Standard). If the result is greater than one, then the exposure is deemed to be unacceptable. According to NOHSC, this method is applicable when the components of the mixture are acting on the same target organ and the effects are believed to be additive (National Occupational Health and Safety Commission 1995b, p. 27).

Adjustment of exposure standards for a 12-hour shift

TWA exposure standards refer to 'the average airborne concentration of a particular substance when calculated over a normal eight-hour working day, for a five-day working week'. At the study location operators work a fly in/fly out roster consisting of 14 twelve-hour shifts in each four-week period. Exposure standards for contaminants with medium term health effects (that is, within a shift or over

Table 1: Exposure standard adjustments used in this study

Atmospheric Contaminant	TWA Exposure Standard (unadjusted)	TWA Exposure Standard (Adjusted)	STEL Exposure Standard (if applicable)
Inhalable Dust	10 mg/m^3	9 mg/m^3	
Nickel	1 mg/m^3	0.9 mg/m^3	
Cobalt	0.05 mg/m^3	0.05 mg/m^3	
Respirable Dust	5 mg/m^3	4.5 mg/m^3	
Respirable Quartz	0.2 mg/m^3	0.18 mg/m^3	
Sulphuric Acid Mist	1 mg/m^3	0.5 mg/m^3	3 mg/m^3
Hydrogen Sulphide	10 ppm	5 ppm	15 ppm
Sulphur Dioxide	2 ppm	1 ppm	5 ppm
Ammonia	25 ppm	13 ppm	35 ppm
Total VOC	350 mg/m^3 [a]	175 mg/m^3	

Note: All unadjusted TWA exposure standards and STELs were sourced from NOHSC (National Occupational Health and Safety Commission 1995b).

[a] The Total VOC standard is a manufacturer recommendation sourced from their MSDS. STEL standards were not adjusted as these apply to acute health effects, which can occur once a certain atmospheric concentration is reached.

a few shifts) were adjusted according to the Brief and Scala Model, while those with long-term effects (that is, over many shifts or years) were adjusted according to a formula based upon the average number of hours worked in a month (National Occupational Health and Safety Commission 1995b, p. 70).

Some contaminants are associated with immediate health effects and these are usually regulated by short-term exposure level (STEL) or peak exposure standards. A STEL exposure is the maximum concentration a person may be exposed to for periods of up to 15 minutes 4 times per day and peak exposures should never be exceeded. STEL and peak exposures were therefore not adjusted for extended shifts (Department of Industry and Resources 1999, p. 2). The 12-hour exposure standards were adjusted as follows (see Table 1).

Results

Samples of contaminants commonly found in each SEG were collected and the data were analysed in order to determine the validity of the SEG classification, this was based on the standard deviation. The results were also compared to the adjusted exposure standards in order to identify problem areas.

Area 1 sample results

In the ore crushing and processing area 7 samples of inhalable dust were further analysed for sulphur and lime, while seven samples of respirable dust samples were analysed for quartz and cristobalite. In all cases the dust concentrations as well as the concentrations of the additional analytes were either negligible or below the limit of detection.

Hydrogen sulphide and sulphur dioxide are used in the preparation of the ore slurry and these gases were also monitored by the collection of seven separate samples. Time weighted average hydrogen sulphide exposures were less than 1ppm (TWA standard = 5ppm). Short-term exposures varied from less than 1 ppm to a maximum of 2ppm (STEL = 15ppm) indicating that the STEL exposure standard was never exceeded. An assumption was made that since the mean exposure for a full shift was below 1ppm, the proportion of STEL results exceeding the exposure standard would be no more than 1.5% (Rappaport et al. 1988).

Sulphur dioxide TWA exposures were less than 0.1ppm (TWA standard = 1ppm). STEL exposures varied from less than 0.1 ppm to a maximum of 1.5ppm (STEL = 5ppm) indicating that the STEL exposure standard was never exceeded. An assumption was made that since the mean exposure for a full shift was below 0.1ppm, the proportion of STEL results exceeding the exposure standard would be no more than 1.5% (Rappaport et al. 1988).

Area 2 samples results

In the utilities production and storage area 4 SEGs were identified and 6-7 inhalable dust samples were obtained from each SEG. One of these samples exceeded the exposure standard (Table 2).

Hydrogen sulphide was monitored through analysis of 6 samples and all TWA exposures were less than 1 ppm (TWA limit = 5 ppm). All STEL exposures were less than 1 ppm (STEL = 15 ppm) indicating that the STEL exposure standard was never exceeded. Since the mean exposure for a full shift was less than 1 ppm, the proportion of STEL results exceeding the exposure standard were estimated to be no more than 1.5%.

Area 3 sample results

In the refinery part of the operation 8 SEGs were identified and a number of samples were collected and analysed (n ranges from 6 to 22 per SEG). Concentrations of toluene, naphthalene, ammonia and volatile organic compounds (VOCs) were found to be acceptable.

Table 3 presents the results of inhalable dust samples collected in area 3. All results were acceptable with the upper level of the range of results for each SEG being within the exposure standard.

Dust samples of 7 SEGs were further analysed for nickel content (n ranges from 18 - 21 samples per SEG). As can be seen in Table 4 the nickel dust concentration in this

Table 2: Summary of results of inhalable dust monitoring in area 2

	SEG 2.1	SEG 2.2	SEG 2.3	SEG 2.4
Exposure Std (mg/m^3)	9	9	9	9
Number of Samples	6	6	7	6
Distribution Type	Log-normal	Log-normal	Log-normal	Normal
Range (mg/m^3)	0.5 to 9.3	0.2 to 0.8	<0.1 to 0.8	<0.1 to 0.9
Mean (mg/m^3)	3.9	0.5	0.4	0.6
95% UCL Mean (mg/m^3)	69	0.9	1.7	0.9
Geometric Std. Dev.	3.4	1.6	2.7	2.7
% Exceedance	12	<0.001	0.01	<0.001

Table 3: Summary of results of inhalable dust in area 3

	SEG3.1	SEG 3.2	SEG 3.3	SEG 3.4	SEG 3.5	SEG 3.6	SEG 3.7	SEG 3.8
Number of Samples	19	18	18	22	22	20	21	6
Exp. Std. (mg/m^3)	9	9	9	9	9	9	9	9
Distribution Type	Log-normal	None	Log-normal	Log-normal	Normal	Log-normal	Log-normal	Log-normal
Range (mg/m^3)	0.3 to 5.2	<0.01 to 3.4	0.2 to 2.2	0.4 to 5.7	0.1 to 2	0.2 to 1.6	0.1 to 1	0.2 to 0.9
Mean (mg/m^3)	1.0	0.8	0.8	1.3	0.8	0.7	0.4	0.5
95% UCL Mean (mg/m^3)	1.4	-	1.1	1.8	1.0	1.0	0.6	1.1
Geom Std Deviation	2.1	4.2	1.8	1.8	1.9	1.9	1.9	1.9
% Exceedance	0.03	0	0.001	0.04	<0.001	0.001	<0.001	<0.001

Table 4: Summary of results of nickel dust monitoring in area 3

	SEG 3.1	SEG 3.2	SEG 3.3	SEG 3.4	SEG 3.5	SEG 3.7
Number of Samples	19	18	18	22	22	21
Exp. Std. (mg/m^3)	0.9	0.9	0.9	0.9	0.9	0.9
Distribution Type	Log-normal	Log-normal	Log-normal	Log-normal	Log-normal	None
Range (mg/m^3)	0.03 to 1.6	<0.01 to 0.32	0.02 to 0.38	0.06 to 3.3	0.03 to 1.1	<0.01 to 0.07
Mean (mg/m^3)	0.20	0.04	0.12	0.58	0.23	0.02
95% UCL Mean (mg/m^3)	0.44	0.1	0.22	0.95	0.38	-
Geo. Std. Deviation	3.1	2.9	2.5	2.5	2.5	2.2
% Exceedance	3.2	0.03	0.5	18	2.8	0

Table 5: Summary of results of cobalt dust in area 3

	SEG 3.1	SEG 3.2	SEG 3.5	SEG 3.6	SEG 3.7
Number of Samples	19	18	22	20	21
Exp. Std. (mg/m^3)	0.05	0.05	0.05	0.05	0.05
Distribution Typenormal	None	None	None	Log-	None
Range (mg/m^3)	<0.01 to 0.12	<0.01 to 0.03	<0.01 to 0.34	<0.01 to 0.52	<0.01 to 0.03
Mean (mg/m^3)	0.02	0.01	0.04	0.14	0.01
95% UCL Mean (mg/m^3)	-	-	-	0.47	-
Geom. Std. Deviation	2.2	1.4	3.8	4.5	1.5
% Exceedance	4.9	0	14	49	0

Table 6: Total additive exposures for operators working in area 1

Operator type	Respirable dust (mg/m^3)	Inhalable dust (mg/m^3)	Sulphuric acid mist (mg/m^3)	Sulphur dioxide (ppm)	Hydrogen sulphide (ppm)	Total additive exposure
SEG 1.1	0.2	1.2	<0.05	<0.1	<1	0.18
Exposure Standard	4.5	9	0.5	1	5	1

Note: In calculating additive results, figures which were less than the detection limit were not included, as doing so would have the effect of artificially increasing the overall result.

Table 7: Total additive exposures for operators working in area 2

Operator type	Inhalable dust (mg/m^3)	Sulphuric acid mist (mg/m^3)	Hydrogen sulphide (ppm)	Total additive exposure
SEG 2.1	3.9	0.07		0.57
SEG 2.2	0.5	0.06		0.18
SEG 2.3	0.4	0.07		0.18
SEG 2.4	0.6	0.05	<1	0.17
Exposure Standard	9 mg/m^3	0.5 mg/m^3	5 ppm	1

Note: In calculating additive results, figures which were less than the detection limit were not included, as doing so would have the effect of artificially increasing the overall result.

Table 8: Total additive exposures for operators working in area 3

Operator type	Inhalable dust (mg/m^3)	Nickel (mg/m^3)	Cobalt (mg/m^3)	Total VOC (mg/m^3)	Ammonia (ppm)	Total additive exposure
SEG 3.1	1.0	0.2	0.02			0.73
SEG 3.2	0.8	0.04	0.01			0.33
SEG 3.3	0.8	0.12				0.22
SEG 3.4	1.3	0.58				0.79
SEG 3.5	0.8	0.23	0.04			1.14
SEG 3.6	0.7		0.14			2.88
SEG 3.7	0.4	0.02	0.01	3.5		0.29
SEG 3.8	0.5				4.8	0.42
Exposure Standard	9	0.9	0.05	175	13	1

area is of concern with a number of exposures recorded above the exposure standard.

Cobalt analysis of 7 SEG samples (n ranges from 18 - 21) also returned a number of results that exceeded the exposure standard (Table 5).

Since all exposures measured have the potential to impact upon the respiratory system they were treated as contaminants with potentially additive effects as a precautionary principle. Tables 5, 6 and 7 summarise the relevant additive exposures for contaminants of concern. Only TWA exposure results are included.

Discussion

Area 1

Area 1 - SEG 1.1

Operators within SEG 1.1 were monitored for exposure to hydrogen sulphide and sulphur dioxide gases, and both inhalable and respirable dust. The inhalable dust samples were further analysed for sulphur and lime content, while the respirable dust samples were analysed for quartz and cristobalite. Exposures of SEG 1.1 operators to all these contaminants and their additive effects were acceptable (Table 6).

Area 2

Area 2 - SEG 2.1

Operators in this SEG were sampled for inhalable dust and sulphuric acid mist. The inhalable dust samples were further analysed for several specific metals. Six inhalable dust samples were collected. One sample exceeded the exposure standard of 9mg/m^3 with a mean value of 3.9. Due to high exposure variability, the 95% upper confidence limit of the mean was well above the exposure standard. Therefore, it could not be concluded with 95% confidence that the mean for all exposures was less than the exposure standard.

Since the GSD was greater than 3, monitoring log sheets were examined in an attempt to establish reasons for the variability. The operator whose result exceeded the exposure standard was also interviewed. From this investigation it was concluded that exposures are heavily influenced by the amount of time spent on one particular cleaning task. On the day of the exposure standard exceedance, the operator stated that he spent more time than usual carrying out the task in question.

The predicted percentage of samples above the exposure standard was also found to be much greater than 5, which indicates that exposure standard exceedances occur on a regular basis. The concentrations of all of the metals analysed in each sample were either negligible or below the limit of detection.

Exposures of SEG 2.1 operators to inhalable dust were deemed to be unacceptable. This situation occurred due to one particular task, which has the potential to greatly increase exposures when it is conducted. Control measures are, therefore, required when conducting the task. At present, this control is achieved via the use of respiratory protection.

Four of the six sulphuric acid mist samples collected were below the detection limit, and the highest result of 0.15mg/m^3 was well below the exposure standard of 0.5mg/m^3. Therefore, exposure to sulphuric acid mist is acceptable. The additive exposures of SEG 2.1 operators to both inhalable dust and sulphuric acid mist are slightly greater than half of the acceptable standard (see Table 7). This is due to the concerns associated with inhalable dust exposures.

Area 2 - SEG 2.2, 2.3 and 2.4

Exposures of SEG 2.2, 2.3 and 2.4 operators to inhalable dust and its potential contents, sulphuric acid mist and hydrogen sulphide as well as their additive effects were found to be acceptable under normal production conditions.

Area 3

Area 3 - SEG 3.1

Nineteen inhalable dust samples were well below the exposure standard of 9mg/m^3, with a maximum exposure of 5.2mg/m^3. However, one of the samples recorded a nickel exposure in excess of the exposure standard of 0.9mg/m^3, and a cobalt level in excess of the exposure standard of 0.05mg/m^3. For both metals these results were four times higher than the next highest result. Further investigation of the log sheets and subsequent interviews revealed that the high result was associated with a specific task - cutting open bags of process scale so they could be emptied. This task released high levels of dust. Once this problem was recognised, the material in the bag was wetted and respiratory protection was worn to reduce exposure.

The estimated means of 0.2mg/m^3 for nickel and 0.02mg/m^3 for cobalt were well below the applicable exposure standards. The mean's one sided 95% upper confidence limit for nickel was 0.44mg/m^3 which is also well below the standard. This value could not be calculated for the cobalt results, as the exposures did not fit either a lognormal or normal exposure distribution. The predicted exposure standard exceedances were 3.2% for nickel, while 5.2% of the results exceeded the cobalt exposure standard (the cobalt percentage is the actual percentage and not a predicted percentage). If the one elevated result discussed above is ignored, then these percentages drop even further. Exposure variability was high (i.e. GSD greater than 3) for nickel and acceptable for cobalt. However, the high variability in nickel results was due to the one outlier as described above.

The exposures of SEG 3.1 operators to inhalable dust, nickel and cobalt are acceptable under normal production activities. However, for certain tasks involving work with dry production materials, exposures to levels in excess of the exposure standard are possible. It is, therefore, necessary to implement exposure control measures prior to conducting such activities.

The additive exposure of the above contaminants was calculated to be 0.73 against the standard of 1 (see Table 8). However, if the one high sample is removed from these results, the additive exposure value drops to 0.47, which is less than half of the standard.

Area 3 - SEG 3.2

Eighteen samples of inhalable dust further analysed for nickel and cobalt and their additive exposures were all found to be well within acceptable limits.

Area 3 - SEG 3.3

Exposures of SEG 3.3 operators to inhalable dust and nickel are acceptable.

Additive exposures were also found to be well within the acceptable limit.

Area 3 - SEG 3.4

Inhalable dust samples (n=22) were further analysed for nickel. None of the inhalable dust samples exceeded the exposure standard, however, three nickel results were either equal to or in excess of the 0.9mg/m^3 exposure standard. The arithmetic mean's one-sided 95% upper confidence limit for nickel was above the exposure standard meaning that it could not be stated with 95% confidence that the mean exposure for nickel was below the exposure standard. The predicted percentage of results exceeding the nickel exposure standard was calculated to be 18%. GSDs for both inhalable dust and nickel were below 3 indicating that the level of variability is acceptable.

Exposures of operators to inhalable dust are acceptable, however, nickel exposures are unacceptable. At present these exposures are being controlled by the use of respiratory protection. The additive exposure calculation of 0.79 is within the acceptable standard of 1 (see Table 8).

Area 3 - SEG 3.5

Twenty-two inhalable dust samples were further analysed for nickel and cobalt. All inhalable dust results were found to be below the exposure standard. One nickel result exceeded the exposure standard, however, the mean and the mean's one-sided 95% upper confidence limit were both below the exposure standard. Three cobalt samples exceeded the exposure standard of 0.05mg/m^3, and the mean exposure was only marginally below the standard. The mean's one side 95% upper confidence limit could not be calculated, as the exposures did not fit either a normal or lognormal distribution. Several elevated cobalt results are believed to have been associated with the drumming of cobalt powders.

The predicted percentage of results exceeding the exposure standard was less than 5% for inhalable dust and nickel. The value for nickel was 3.5%; this value could not be calculated for cobalt, as the exposures did not fit either a lognormal or normal distribution. GSDs were acceptable for inhalable dust and nickel, but were above 3 for cobalt. The reason for the high cobalt GSD is that packaging operators do not always package cobalt, and as a result, several cobalt exposures were found to be less than the limit of detection. That is, a high level of variability occurs when these low results are combined with the higher results obtained from monitoring during which cobalt packaging was occurring. This SEG should, therefore, be split into two - one SEG for when packagers work with both nickel and cobalt, and one SEG in which they only package nickel.

It was thus inferred that the exposures of packaging operators to inhalable dust is acceptable, the exposures to nickel are only marginally acceptable and require continued vigilance, and their exposures to cobalt are unacceptable. At present, operator exposures are being controlled via the use of respiratory protection. In order to get a more accurate picture of exposures it is recommended that this SEG be split into two as outlined above.

Additive exposures were above the acceptable value due to the unacceptable exposures to cobalt (see Table 8).

Area 3 - SEG 3.6

All inhalable dust results were found to be below the exposure standard. Eleven of the 20 results were either equal to or in excess of the 0.05mg/m^3 exposure standard for cobalt. The predicted percentage of results which would exceed the exposure standard was less than 5% for inhalable dust, but 49% for cobalt. The GSD for inhalable dust was acceptable; however, the calculated value of 4.5 for cobalt was well above the acceptable value of 3. The reasons for this variability are not clear.

Exposures of operators to inhalable dust were acceptable, however, their exposures to cobalt are unacceptable. At present, these exposures are being controlled via the use of respiratory protection. Additive exposures are above the acceptable value due to the cobalt exposures (see Table 8).

Area 3 - SEG 3.7

Exposures of operators to inhalable dust, nickel and VOCs are acceptable. Additive exposures were also found to be well within the acceptable limit (see Table 8).

Area 3 - SEG 3.8

All inhalable dust levels were found to be within acceptable levels. Ammonia concentrations were found to be below the TWA and STEL exposure standards in spite of some short-term excursions of up to 97 ppm being recorded during certain high exposure tasks. The high exposure tasks were investigated and found to be associated with the release of ammoniated water and the unloading of ammonia trucks. Respiratory protection was being used to control exposures. Alarms that warn of high ammonia concentrations have also been installed.

The greatest health risk posed to this SEG is associated with their exposure to high short-term concentrations of ammonia. The process of identifying high exposure activities, therefore, needs to be continuous to ensure that appropriate control measures are put in place prior to work commencing. Additive exposures for operators were calculated to be acceptable (see Table 8).

Conclusion

Exposure of operators to inhalable dust in SEG 2.1 were found to be unacceptable. In the refinery, furnace operators from SEG 3.4 had unacceptable exposures to nickel. SEG 3.5 packaging operators and SEG 3.6 operators had elevated exposures to cobalt. It must be noted, however, that the operators in these areas were required to wear respirators while engaged in tasks that generated the high exposure scenarios and thus the health of workers was being protected.

Each of the above SEGs require further study to identify potential control options, which should be considered in the following order of preference:

- elimination of the process, equipment, or material giving rise to the exposure;
- substitution with a less hazardous process, equipment or material;
- engineering controls (e.g. process modification, enclosure, exhaust ventilation, shielding, damping);
- work practice controls and employee training;
- administrative controls;
- proper selection, fitting, and use of personal protective equipment

(Mulhausen & Damiano 1998, p. 156).

In the case of SEG 3.4 Furnace Operators, SEG 3.5 packaging operators and SEG 3.6 operators, the high exposures were all occurring inside either the nickel packaging shed or the cobalt packaging shed. Before entry into either of these sheds, it is necessary to wear a P2 respirator. In order to move away from the use of respirators, it will be necessary to implement controls that are higher up the hierarchy. Some extractive ventilation systems are present in both packaging sheds; however, improvements need to be made and in the interim respiratory protection will be required.

The unacceptable inhalable dust exposures of SEG 2.1 operators appear to be due to one task, namely cleaning under the sizer. At present, this is controlled through the use of P2 respirators. As outlined for the other unacceptable SEGs, work should be conducted to identify longer-term controls, which rank higher in the hierarchy.

The use of the monitoring log sheets proved to be a valuable exercise. The sheets were developed with input from operators from each area of the plant. The purpose-designed sheets allowed operators to provide details about the tasks they were performing simply and quickly. This information proved to be invaluable in terms of identifying potentially high exposure tasks and how often they were occurring.

The results of this study provided a much more detailed understanding of the level of health risks posed to production operators at the mine site, which in turn enabled the management to direct resources appropriately.

Recommendations for future sampling

In order to develop an historical database of exposures, and to monitor the exposure situation over time, it is recommended that monitoring is continued indefinitely and according to a pre-established protocol.

Sampling protocols should be based upon the conclusions drawn from the results of an initial exposure assessment (that is, taking sufficient samples within each SEG). The principle involved in developing a sampling protocol is based upon the mean exposure and how it compares to the exposure standard:

- for extremely low exposures, it is unlikely that any single exposure could exceed the exposure standard so sampling frequency decreases;
- for extremely high exposures, it is necessary to immediately implement exposure controls. Only then would further monitoring be required thus sampling frequency decreases;
- as mean exposures approach the exposure standard, more samples are required to confidently state whether or not exposures exceed the exposure standard (European Committee for Standardization 1995).

The minimum sampling frequency recommended by the European Committee for Standardization (1995) is 16 weeks. In the Australian context, however, seasonal variation would impact on dust levels and therefore more regular monitoring is recommended as shown in Table 9.

Table 9: Recommended Future Sampling Program

Operator	Recommended sampling frequency
SEG1.1 - Hydrogen Sulphide	As required
SEG1.1 - Sulphur Dioxide	As required
SEG1.1 - Inhalable Dust	1/month
SEG1.1 - Respirable Dust	1/month
SEG2.1 - Inhalable Dust	1/month
SEG2.1 - Sulphuric Acid Mist	1/month
SEG2.2 - Inhalable Dust	1/quarter
SEG2.2 - Sulphuric Acid Mist	1/quarter
SEG2.3 - Inhalable Dust	1/quarter
SEG2.3 - Sulphuric Acid Mist	1/quarter
SEG2.4 - Inhalable Dust	1/quarter
SEG2.4 - Sulphuric Acid Mist	1/quarter
SEG2.4 - Hydrogen Sulphide	As required
SEG3.1 - Inhalable Dust	1/quarter
SEG3.2 - Inhalable Dust	1/quarter
SEG3.3 - Inhalable Dust	1/quarter
SEG3.4 - Inhalable Dust	1/month
SEG3.5 - Inhalable Dust	1/month
SEG3.6 - Inhalable Dust	1/month
SEG3.7 - Inhalable Dust	1/quarter
SEG3.7 - VOC	1/quarter
SEG3.8 - Inhalable Dust	1/quarter
SEG3.8 - Ammonia	As required

From this Table, the following should be noted:

1. Gases are shown as 'not applicable' as they are not compatible with random sampling programs;
2. Gases are recommended for monitoring on an 'as required' basis, meaning that further work is only required if a problem arises with a specific task or exposure situation;
3. Inhalable dust samples should continue to be analysed for

their potential contents. The recommended sampling frequencies are based upon either the worst case constituent of the inhalable dust, or where all constituents have been shown to be present in extremely low concentrations, the inhalable dust result itself.

4. For most operator types, significant historical data did not exist prior to this monitoring program. As a result, sampling frequencies have been increased to ensure that potential seasonal variations are accounted for.
5. For operators found to have unacceptable exposures, monitoring frequencies have been increased to ensure that these problem areas are monitored on a regular basis.

If the exposures of any of the various operators were to change dramatically due to the introduction of additional exposure controls or a significant change in the process, then a new monitoring program would need to be implemented. This would involve starting again and taking six samples per SEG.

References

American Society for Testing and Materials 1999, D 4856 - 99 - Standard Test Method for Determination of Sulfuric Acid Mist in Workplace Atmosphere (Ion Chromatographic), American Society for Testing and Materials, pp. 3.

Department of Industry and Resources, *Adjustment of Exposure Standards for Extended Workshifts*, Vol. 1, Mines Occupational Safety and Health Advisory Board, Department of Industry and Resources, Perth.

European Committee for Standardization 1995, EN 689 - *Workplace Atmospheres: Guidance for the assessment of exposure by inhalation to chemical agents for comparison with limit values and measurement strategy,* European Committee for Standardization, Brussels.

Guest, I.G., Cherrie, J.W., Gardner, R.J. & Money, C.D. 1993, British Occupational Hygiene Society Technical Guide No. 11 - Sampling Strategies for Airborne Contaminants in the Workplace, British Library, Leeds, UK.

Health and Safety Executive 1989, *Monitoring Strategies for Toxic Substances*, Health and Safety Executive, London.

Leidel, N.A., Busch, K.A. & Lynch, J.R. 1977, *Occupational Exposure Sampling Strategy Manual,* National Institute of Occupational Safety and Health, Ohio.

Mulhausen, J.R. & Damiano, J. 1998, *A Strategy for Assessing and Managing Occupational Exposures*, Vol. 1, American Industrial Hygiene Association and the Exposure Assessment Strategies Committee, Virginia.

Murdoch, C., Foster, G. & Geyer, R. 2002 *Sulphuric Acid Mist: A Critical Examination of Some Monitoring Methods* <www.aioh.org.au> February 2004.

National Occupational Health and Safety Commission 1995a, *Exposure Standards for Atmospheric Contaminants in the Occupational Environment: Guidance Note on the Interpretation of Exposure Standards for Atmospheric Contaminants in the Occupational Environment [NOHSC:3008(1995)] and Adopted National Exposure Standards for Atmospheric Contaminants in the Occupational Environment [NOHSC:1003(1995)],* 3rd edn, updated for amendments <www.nohsc.gov.au/OHSInformation/NOHSCPublications/fulltext/docs/h4/GN3008_5A.htm> 1 December 2005.

National Occupational Health and Safety Commission 1995b, *Exposure Standards for Atmospheric Contaminants in the Occupational Environment: Guidance Note on the Interpretation of Exposure Standards for Atmospheric Contaminants in the Occupational Environment [NOHSC:3008(1995)] and Adopted National Exposure Standards for Atmospheric Contaminants in the Occupational Environment [NOHSC:1003(1995)],* May 1995 edn, Australian Government Publishing Service, Canberra.

Rappaport, S.M. 1991, 'Assessment of long-term exposures to toxic substances in air', *Annals of Occupational Hygiene*, vol. 35, no. 1, pp. 61-121.

Roach, S.A. 1977, 'A most rational basis for air sampling programs, *Annals of Occupational Hygiene*, vol. 20, pp. 65-84.

Standards Australia 1987, *AS 2985 - 1987 Workplace Atmospheres: Method for Sampling and Gravimetric Determination of Respirable Dust*, Standards Australia, Sydney.

Standards Australia 2003, AS 2986.1 - 2003 *Workplace Air Quality: Sampling and Analysis of Volatile Organic Compounds by Solvent Desorption/gas Chromatography, Part 1: Pumped Sample Method*, Standards Australia, Sydney.

Standards Australia 2004, *AS 3640 - 2004 Workplace Atmospheres: Method for Sampling and Gravimetric Determination of Inhalable Dust*, Standards Australia, Sydney.

Correspondence to:
Jacques Oosthuizen
Centre for Public Health, School of Exercise, Biomedical and Health Sciences
Edith Cowan University
100 Joondalup Drive
Joondalup, Western Australia 6027
AUSTRALIA
Email: j.oosthuizen@ecu.edu.au

Back to TOC

Curriculum Development, Accreditation and Quality Assurance in University Environmental Health Education

Lyn Talbot[1], Erica L. James[2], Glenda Verrinder[1] and Paul Jackson[1]

[1]Department of Health and Environment, School of Public Health, La Trobe University & [2]Centre for Health Research and Psychoncology (CHeRP), Cancer Council NSW & University of Newcastle

There have been considerable efforts to develop recognised workforce competencies, also known as 'literacies', for the environmental health workforce. In this paper we describe a case study from the Bachelor of Public Health (Environmental Health) provided at the Bendigo campus of La Trobe University, Victoria, to describe how environmental health literacies have assisted the process of curriculum development, accreditation, and ongoing quality activities. First, we describe the role literacies played in assessment of a preexisting bachelor program and how the literacies helped to identify strengths and gaps in the environmental health curriculum. Second, we discuss how the development of curriculum-literacy maps can provide valuable documentation to support AIEH accreditation reviews. Finally, we describe how we have successfully incorporated the curriculum-literacy mapping exercise described above into our on-going five-year quality assurance (QA) data collection cycle in order to help satisfy both internal QA and external accreditation requirements, and reduce the peaks and troughs in quality data collection activity. We recommend that other academic departments consider utilising literacies to assist accreditation and QA activities.

Key Words: *Competencies; Literacies; Workforce; Environmental Health; Curriculum; Training; Quality Assurance*

Environmental health (EH) practice has a long history that is often considered to have commenced with the declaration of the Public Health Act 1848 in England and Wales. Other important milestones include the formation of the Sanitary Inspector's Association in England in 1883. In Australia, the concept of environmental health was adopted by new immigrants from England in response to the sanitary conditions of the new colony. Organisations like the Sanitary Inspectors' Association of NSW established in 1912, the Health Inspectors' Society of NSW established in 1915, the Cordon Sanitaire in the 1920s, and the Australian Institute of Health Surveyors formed in 1936, were the conceptual beginning of the Australian Institute of Environmental Health (AIEH) as we know it today (AIEH 2006).

Environmental Health Officers (EHOs) were not always known as such. Among other names they were called Sanitary Inspectors, Health Surveyors, Health Inspectors and Nuisance Inspectors. EH has expanded beyond hygiene and sanitation into all aspects of the environment which affect our health, including disaster management, communicable diseases, indigenous health, noise assessment, air and water quality, wastewater management, and food safety. The AIEH has grown from a group of fewer than a dozen untrained workers, to a professional group of over 2000 members with a clearly defined role in our community.

In Victoria until 1979, people wanting to train as EHOs undertook a two-year part-time Certificate issued by the Royal Society of Health. In 1979, Swinburne Institute of Technology developed a three and a half-year

Diploma of Applied Science (Environmental Health) and this was later converted to a four-year Bachelor of Applied Science (Environmental Health) in 1985. This course provided the only option for EH professional training in Victoria until the introduction of the La Trobe University, Bendigo program in 2000.

To help in ensuring professional excellence in the science and practice of EH, the AIEH has a commitment to workforce development and training. As the significance of the environmental health profession gains momentum, and more universities are looking to establish EH degree courses, the AIEH has increased its role in accrediting universities to conduct training of EHOs. One of the key processes in achieving appropriate training and education of EHOs is the AIEH Accreditation Scheme and Educators' Forum.

Minimum requirements to constitute a sound EH degree program are discussed at the annual AIEH Educators' Forum, to which all participating universities are invited. Accreditation allows graduates to practise as an EHO around Australia and assures employers that all graduates have comparable background and training.

> *The advantage of this is clear. A uniform and consistent approach will inject a high level of standard into our profession by ensuring our ambassadors, the students, all meet the minimum EHO requirement. The other advantage is for employers, knowledge that all graduates of AIEH Accredited Programs are of the same high calibre and they can hire with confidence in the knowledge that they have the same level of training and education. In the AIEH Accredited Program, it is also our aim to work with all universities to actively promote an EHO course that meets the standard, not only to maintain the high level of professionalism, but also to increase the popularity of our profession (Lau 2005).*

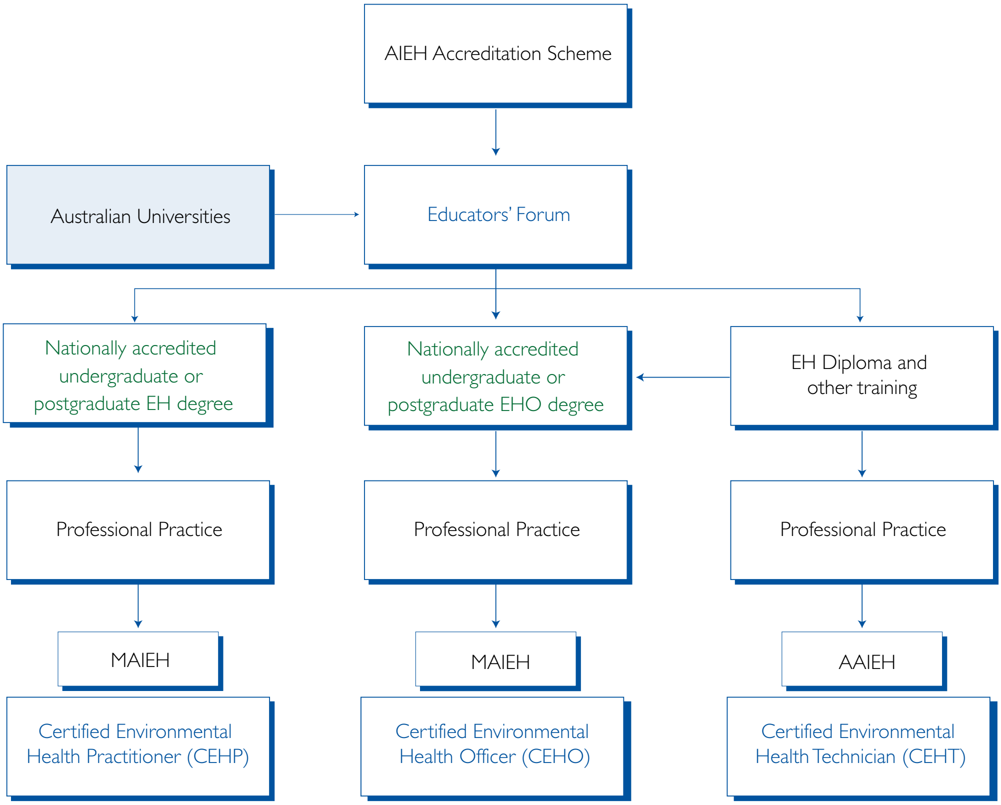
Just as universities and professional employers are expecting graduates to demonstrate relevant competencies or literacies, educators must develop curriculum programs in an evidence-informed manner. That is, based on research about the knowledge and skills required for practice, rather than purely on intuition or tradition. There have been considerable efforts to develop recognised workforce knowledge and skills. These have been expressed as health promotion competencies (Shilton et al. 2001), and for the EH workforce they are known as 'literacies'.

In this paper, we use the terms competencies and literacies interchangeably to describe a set of graduate attributes that the workforce has defined as desirable for professional practice. Identified core literacies for environmental health, or other areas of applied professional practice, provide evaluation criteria for ascertaining whether or not the literacies have been achieved by the relevant workforce (Redman & O'Hara 2003). In this respect, literacies can be used as a policy lever to ensure adequate workforce development funds are allocated. They can also be used as a lever by the accrediting body (in this case the AIEH) to ensure universities offer curriculums that enable graduates to attain necessary attributes for practice.

The use of workforce literacies to assist curriculum planning provides a mechanism for creating a link between theoretical frameworks and applied practice. Mapping a curriculum against workforce competencies or literacies also provides an evidence based framework for the selection of topics, activities and assessment tasks in university education (Talbot, Graham & James 2007).

The main criticisms raised in the literature about using workforce competencies to inform university course development are the lack of debate about the validity of national competency standards, and the tendency for their use to lead towards 'universalism' in attributes (Mendoza et al. 1994). When the term competencies is used synonymously with *skills*, a narrow and prescriptive approach to defining competencies can result (Ife 2002). This narrow view is clearly inappropriate for community based workers, such as EHOs, given the fluid and context-specific nature

Figure 1: Flow Chart of AIEH Accreditation Scheme



Source: Lau, W. 2005

of their work skills (Ife 2002), and also their professional requirements to enforce strict legislative protocols. It is also important that generic competencies are not applied to a workforce as though workers are homogenous in their practice. Instead, competencies need to take account of broad principles reflected in policy and legislation, which might vary between states or localities. For example, Shilton and colleagues (2003) identified variations in perceptions of essential or core competencies between urban and rural health promotion practitioners. Another potential shortcoming of developing EH literacies and using them to guide curriculum design in the university sector is their need to be sufficiently broad to be applicable across different state-based legislation, while simultaneously equipping practitioners in the field to undertake the huge legislative responsibilities enshrined in their professional role. Despite these criticisms, the requirement for course coordinators to enable students to achieve broad literacies does cut down the 'territorialism' and subjective judgements of quality made in comparisons between courses, or by those external to the field who purport to know what EH practitioners need.

Aim

This paper describes a case study of how published EH literacies were used to guide the development of an undergraduate EH course, and how a process of curriculum-literacy mapping has assisted both accreditation processes with the AIEH and ongoing university quality assurance activities.

La Trobe University has eight campuses across the state of Victoria. The Bachelor of Public Health (BPH) program described here is provided at the Bendigo campus. The City of Greater Bendigo is situated in central Victoria 150 kilometres northwest of Melbourne. It is one of the largest regional municipalities in the state with a population of just over 94 000 (Greater Bendigo City Council 2006). The Bendigo campus caters for about 4000 students. The BPH program at Bendigo provides education and training for the health promotion and EH workforce. As the first such program in rural Victoria, it was established in 1993 to provide relevant, accessible and high quality public health education for regional and rural students. The BPH course is informed by a primary health care philosophy and has themes in social, behavioural and life sciences, research and epidemiology, health systems and health policy. It currently offers students the choice of major stream in either EH or health promotion/health education. The curriculum can be viewed at www.latrobe.edu.au/handbook/bendigo/. At La Trobe University we refer to a *course* with major *streams* that consist of individual *units* (or subjects).

Literacies as a Tool to Aid Curriculum Development

The original BPH (Health Promotion) course was developed in 1993 in response to demand for health professionals specifically qualified in public health/health promotion. It was characteristic in the emerging health promotion workforce at that time for new staff to be appointed directly from their practice in other disciplines. Health promotion practitioners then found themselves working in roles for which they were significantly under-prepared. Despite the health promotion focus, the original curriculum included two units that specifically made the links between the physical environment and health. Following advice from the 1998 Course Advisory Committee, which consisted of an expert panel of academics, students and industry representatives, two additional EH units were added to the course, thus enabling students to choose either a *health promotion* or an *environmental health* major stream of study.

The strengthening of the EH stream in the BPH program has been an iterative process. Over a similar time period, EH literacies have been developed and refined by the AIEH. The content introduced into the original BPH program and the development of the EH major stream was informed by the National Environmental Health Strategy (Commonwealth of Australia 1999a) and preceding discussion papers (Commonwealth of Australia 1998; Madden & Salmon 1999; NSW Health Department 1998). Key EH conferences in 1999 (Commonwealth of Australia 1999b) and 2000 (Commonwealth of Australia 2000a; Peach 2000) provided further direction.

The then National Environmental Health Forum, the Public Health Association and the AIEH joined forces in 1999 to refine the work that had been done in developing the National Environmental Health Strategy. *Environmental Health Practitioners: Future Challenges, Future Needs* (Commonwealth of Australia 1999b) was timely for the strengthening of EH literacies within the BPH (EH) as educators, policy makers and EH practitioners came together to examine trends and pressures facing EH practitioners with a view to establishing mechanisms to support workforce development. Undergraduate and postgraduate training, in-practice training, and continuing professional development were all discussed. Generic and specialist skills were strongly debated. Discussion and recommendations from this informed the National Environmental Health Strategy (Commonwealth of Australia 1999a) and provided guidance for the development of the literacies in the BPH (EH).

The EH Symposium on Education, Research and Workforce in 2000 (Commonwealth of Australia 2000a) helped to fine-tune the undergraduate degree in time for final preparation for the first AIEH accreditation review later that year. A common understanding was reached on the broad workforce capacity building required to enable existing and future practitioners to deal with EH issues. Core concepts and principles underpinning EH practice and key workforce issues, core skills and literacies (both general and specific) were identified. Broad goals, strategies and activities needed to build workforce capacity in undergraduate education, postgraduate education, continuing professional development and research were identified and agreed, resulting in the national *Environmental Health Risk Assessment Public Consultation Report* (Commonwealth of Australia 2000b).

The principles that underpin content in the units of the BPH (EH) are those outlined in the Australian Charter for Environmental Health (Commonwealth of Australia 1999a). Leading up to the first accreditation process for the BPH (EH) the principles, activities and literacies in the charter were 'mapped' against each of the units within the course, to identify strengths and gaps. The aim, objectives and unit description were examined against each principle in the Charter. The results of this step identified that all principles except for 'risk-based management' were addressed in the existing BPH (EH) curriculum. Two new units needed to be added to ensure the EH risk assessment and management literacies could be met in the course (Table 1). In addition, some units needed to be modified to clarify the intention of the EH principles. For example, the principles of 'equity' and 'partnership' outlined in the Charter have always been clearly articulated in the objectives of existing units in the course, such as *Health Systems* and *Public Health Principles*, and the assessment tasks help ensure that competencies are met by students. However, while the principle of 'local and global interface' was a clear expectation in the assessment tasks of the unit *Environmental Health*, adjustment had to be made to the unit description and objectives to improve clarity. In 2001 the BPH (EH)

Table 1: Details of unit added to the BPH curriculum, Environmental Health Management A

Aims

The purpose of this unit is to introduce students to EHpractice and the role of the EHpractitioner. There are four major areas of study in this unit:

a. risk management
b. risk assessment
c. EH hazards such as those associated with air, water and soil pollution
d. health and environmental legislation

Objectives

Upon successful completion of the unit, students should be able to:

1. Demonstrate an understanding of the principles underpinning EH practice
2. Identify and describe the nature of EH hazards that can be biological, chemical, physical, mechanical and/or psychosocial
3. Demonstrate an understanding of, and skills to apply, risk management, risk assessment and health impact assessment techniques
4. Have basic knowledge of complaints and nuisance investigation in a local government context

Australian Charter For Environmental Health-Principles Environmental Health Risk Assessment and Management

- The determinants of health in the environment, ie. physical, chemical and biological stressors and pollutants that affect population health
- Risk framework outlining the scientific method of environment health risk assessment which incorporates epidemiology and toxicology
- Science of EH hazards and pollutants including the importance of research to provide new evidence
- Exposure assessment of EH hazards
- Risk assessment and risk management practices pertaining to a range of EH issues, and in particular for food safety; environmental pollution/protection - contaminated land, solid and hazardous wastes, water and wastewater, air and noise pollution, dangerous goods and the built environment.

was accredited by the AIEH for five years. Curriculum-literacy mapping has assisted ongoing accreditation processes for the BPH (EH), and this is described on the previous page.

Literacies as a Tool to Assist Accreditation Processes

The second accreditation process for the BPH (EH) occurred in 2005. As part of the usual Course Review processes required by the University, in 2004 staff in the teaching team undertook to map the Australian Health Promotion workforce competencies (Shilton et al. 2001) against the course documents of the BPH (HP). In this way, content gaps, duplications and sequencing problems in the existing course were identified. A separate map for each unit was made which contained the unit aim, objectives, and the lecture program and assessment details. A number of the units in the BPH are common across both the EH and HP streams. A research assistant, who was a graduate of the program, was employed to check each unit for internal consistency; to see that there was a clear link between lecture content or assessment activities, and the aim and objectives of the unit. She was able to identify where this match did not occur, such as when an objective was not covered in the lecture program, or when there were 'loose' lectures with no clear link to the objectives. The research assistant was also able to identify where content from different units was duplicated. She then mapped the content against all health promotion competencies (Shilton et al. 2001), and noted which competencies were met, to what level, and how many times. Teaching teams from each of the units were required to check these notes and amend the objectives, content or assessment profile accordingly, so the units would enable students to achieve the maximum number of competencies. Where competencies could not be achieved within the course it was because they required further development in a professional practice role, which is outside the university role (Shilton et al. 2003).

When the cycle of review and reaccreditation of the BPH (EH) was due in 2005, department staff undertook to use the same process of curriculum-literacy mapping, this time adding the EH literacies to the grid for each of the units which are common to both streams in the course, and making a new grid for the units that are offered specifically to the EH students. The following example illustrates the process.

The unit *Human Ecology and Health* is a first year, second semester unit offered to students enrolled in both streams of the BPH. It is preceded in the first semester by a basic human biology, anatomy and physiology unit. As shown in Table 2, the unit Aim and Objectives were already in place and provided the basis for development of the lecture program and assessment tasks. Previous mapping of this unit against the Australian Health Promotion competencies (Shilton et al. 2001) identified two competencies which successful completion of this unit enabled students to achieve. These were to:

P1: *Critically analyse relevant literature*, and

K3: *Apply knowledge of structure and function of the human body to health issues and diseases*.

The Health Promotion competencies are presented in a table form, where the letter indicates the broad theme of the competencies, and the number relates to a specific competency statement. For example Health Promotion competency K3 relates to the third statement in the broad competency theme of 'Knowledge'. The EH Literacies and descriptors are expressed in a similar manner. The corresponding EH literacies were added to each unit map (Table 2) indicating which literacies and graduate attributes could be met by successful completion of the unit. The EH Literacies are italicised and the descriptors are shown as dot points.

Table 2: Unit grid for Human Ecology and Health

Aims

The purpose of this unit is to introduce students to the idea that health is determined by the relationship between humans and the environment in which they live.

Objectives

Upon successful completion of the unit, students should be able to:

1. Describe the characteristics of the relationship between humans and their environment in biological and psychosocial terms;
2. Apply knowledge of the structure and function of the human body to health issues and diseases;
3. See the history and future of humanity as a series of biological and cultural adaptations;
4. Understand the relationship between humans and microbes;
5. Distinguish between biological and cultural adaptations and be able to apply the prerequisites for successful cultural adaptation.

Assessment

Assessment 1: 1250 - 1500 word assignment (30%) on the following topic: Discuss the proposition that human heath is a function of the relationship between humans and the environment in which they live. Include specific examples.

Assessment 2: One microbiology practical write-up, 400 word maximum (10%).

Assessment 3: Examination (60%).

Health Promotion Competencies

P1, K3

Environmental Health Literacies And Graduate Attributes

Public Health Principles

- International public health issues and initiatives eg. Health for All, Ottawa Charter;
- The interaction between human lifestyles, consumption patterns, urbanisation and health;
- Social inequalities in health;
- The role of cultural, social and behavioural factors in determining health status and the delivery of health services;
- The health status of populations; determinants of health and illness specific to populations; factors contributing.

Sustainable Development & EH Principles

- The concept of environmental determinants of health;
- Links between good health and the state of the environment; protection from risk to health
- Impacts of global and local pollution and environmental degradation;
- Resource depletion and consumption and environmental protection ;
- Think globally

The following semester, students undertake the unit *Environmental Health*. The unit map (Table 3) illustrates the ways in which, as the students' knowledge base is gradually built upon, they are able to achieve more literacy descriptors within each broad literacy area. The map also illustrates the ways in which assessment requirements build upon students' ability to achieve competence.

To complete the illustration, by the time students reach third year and undertake the unit *Environmental Health Case Studies*, they are able to achieve all the descriptors within a given literacy (note that they take the unit *Epidemiology*, concurrently - Table 4).

Unit competency/literacy grids were provided to the AIEH assessors prior to the accreditation review visit and provided the framework for interviews between assessors and teaching staff. The maps provided transparency to the process and clearly demonstrated the crucial links between the course curriculum and desired graduate attributes.

Curriculum-Literacy Mapping as Part of On-Going Quality Activities

The final area of activity for discussion in this paper is where curriculum-literacy mapping has been useful in the area of quality

Table 3: Unit grid for Environmental Health

Aims

The aim of this unit is to provide the opportunity for students to develop a greater understanding of the interrelationship between the physical environment and human health in preparation for public health practice.

Objectives

Upon successful completion of the unit, students will be able to:

1. Discuss the interdependence of humans and their physical environment
2. Discuss the relationship between some of the content themes and health
3. Develop an understanding and outline some of the theoretical and action frameworks that public health practitioners can use to promote, protect and restore the health of the planet and consequently human health
4. Discuss the interrelationship between EH & social justice;
5. Critically appraise the EH literature;
6. Develop skills in communicating EH issues to a wide range of audiences through report writing

Assessment

Assessment 1 - 2,000 - 2,500 word assignment (50%)

Literature review focusing on a theme of significant environmental importance such as climate change, ozone depletion, soil quality, water quality and scarcity, air quality, population increases and consumption patterns or biodiversity.

Part A

Thinking globally, provide an overview of the global EH issues relating to the theme above. Discuss the actual or potential long and short-term impacts for the world.

Part B

Thinking globally, identify actual or potential health risks to members of a local community that have developed because of the factors associated with global conditions of change discussed in Part A. These will be local public health issues which also have relevance for people everywhere.

Assessment 2 - One 2-hour examination (50%)

Comprising: short answer questions (15%) , Multiple choice (15%), discussion - short essay (15%)

Health Promotion Competencies

N2, P1, K1, K6, I10

Environmental Health Literacies And Graduate Attributes

Public Health Principles

- International public health issues and initiatives eg. Health for All, Ottawa Charter.
- The interaction between human lifestyles, consumption patterns, urbanisation and health.
- Social inequalities in health.

Sustainable development & EH Principles

- The historical development and current paradigms pertaining EH in Australia and overseas;
- Links between good health and the state of the environment
- Principles of EH justice and equity
- Promoting healthy environments through sustainable development thinking
- The complexity of population change, resource management and climate change
- The links between environment and society, economics and environment, politics and environment, and EH development
- Principles of environmental protection, ecologically sustainable development and the precautionary principle
- Impacts of global and local pollution and environmental degradation
- Resource depletion and consumption and environmental protection

Foundation sciences

- Basic environmental toxicology

Table 4: Unit grid for Environmental Case Studies

Aims

This unit examines how scientific studies may be applied to:

- Determining the origin, nature and quality of land and water resources;
- Assessing the impacts of using resources on the quality and diversity of the biophysical environment;
- Identifying and monitoring environmental change - past, present and future;
- Assisting balanced decision-making in the sustainable use of resources.

The unit is based around field studies of the physical and biological components and the dynamics of selected ecosystems. Lecture and practical classes provide a background for, and follow-up to those field studies.

Objectives

By the completion of this unit students will be able to:

1. Identify and source data on the health risks of individuals and communities
2. Identify behavioural, environmental and organisational factors that promote or compromise health
3. Identify process that are effective in assessing risks and setting priorities for environmental management
4. Demonstrate knowledge of the health system and broader systems that impact on health;
5. Identify appropriate evaluation designs

Assessment

Assessment 1: Participation and contribution in field and other class activities, including course diary (10%).

Assessment 2: Written project 2,000 words (25%).

Assessment 3: Exam (25%).

Assessment 4: Class presentation (20%)

Assessment 5: Poster presentation (20%).

Environmental Health Literacies And Graduate Attributes

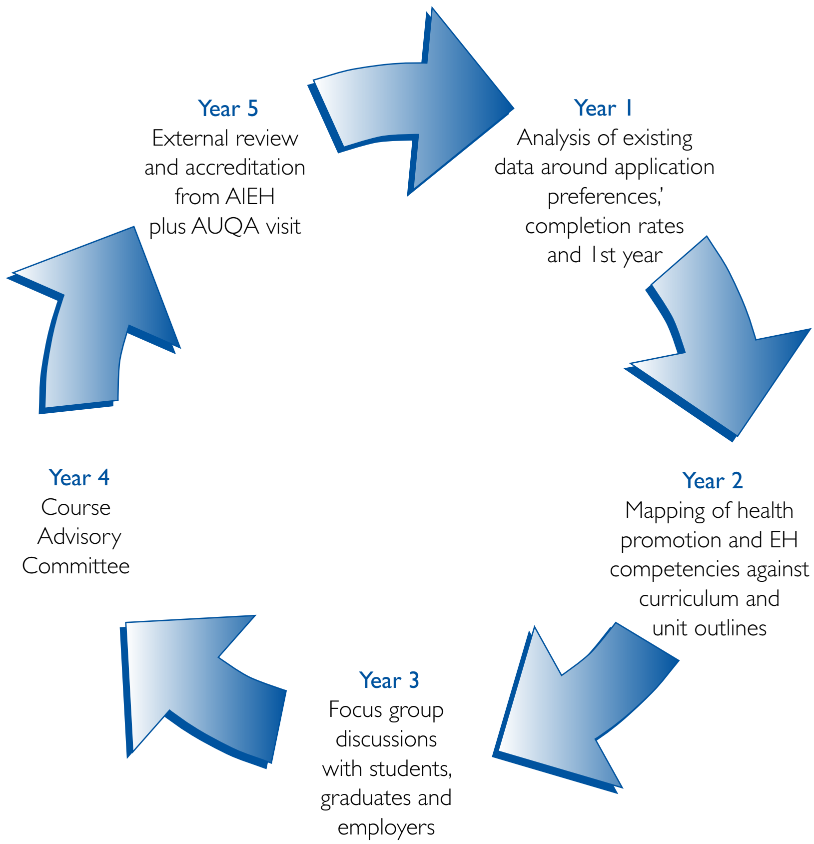
Environmental Health Management & Administration

- Historical development, structure and interaction of public and EH and health care system
- Purpose and functions that an EH service provides, including EH and protection programs, risk management, risk communication, intersectoral cooperation, community consultation, education, training and research
- Formulation and implementation of strategic policies relating to .EH matters, and their evaluation of the impact
- The role of cultural, social, and behavioural factors in determining the delivery of government EH services
- Political and economic influences and implications EH management and administration
- Methods for interacting sensitively, effectively, and professionally with persons from backgrounds and preferences
- Elements of organisational behaviour including the behaviour of the individual, groups, community and the workplace
- Environmental health auditing
- Provision of EH advice to management and the community
- Research capability to interpret data and reports and to enable proactive responses to future issues
- Management of EH projects, including budgetary and financial processes

assurance (QA). Universities are responsible for delivering programs of sound quality to students and are required to report the results of their QA processes through the Australian Universities Quality Assurance (AUQA) audit process. Similarly, students have reasonable expectations of having programs of sound and reliable quality that meet their expectations. Academic and Course administration staff need to be constantly aware of the parallel processes of University QA and external accreditation, to ensure that they have documented evidence of their ability to meet the requirements of each agency, and that any alterations made to a course do not reduce their ability to meet quality and accreditation requirements.

Therefore, sources of quality data that can satisfy both internal QA and external accreditation requirements are very appealing, because there is significant workload involved in the processes of consulting with graduates, experts in the field, and other community members and subsequently reporting these data. The curriculum-literacy mapping exercise described above has been successfully incorporated into the on-going five-year QA data collection cycle of the department (Figure 2). As described in Figure 2, each year the Department undertakes one round of data collection or synthesis. In the first year, a trend analysis of all existing data sources such as enrolment numbers, percentage of completions and feedback from evaluation of the first year experience program and national graduate exit survey data is undertaken. This is followed in the second year by the curriculum-competency mapping update that is undertaken for the most recent version of the health promotion competencies and EH literacies. In the third year of the cycle, focus group discussions are conducted with current students, graduates, and employers prior to the Course Advisory Committee in the fourth year. In the final year of the data collection cycle external accreditation visits are undertaken with AIEH and AUQA. For a more detailed overview of this process see James et al. (2006). In this way, both the literacy-mapping exercise and the AIEH visit are integrated into our quality activities.

Figure 2: Department of Health and Environment 5 year quality data collection cycle



Potential complexities in the processes need to be considered in the planning stage. The process of competency mapping of the initial course against health promotion competencies was undertaken by a research assistant (RA). While it would be possible for existing staff to do this, it is a significant load. There are two clear advantages of using a RA familiar with the course, but not intimately involved with its offering. The first advantage is that the RA is able to give the process undivided attention. Timing is important, because if units need to be altered it must be in the 'window' in an academic year that allows amendments to progress through the relevant committee structures and to be appropriately reflected in course handbooks. The second advantage is that an outsider checks carefully the internal consistency and integrity of what is written explicitly in the documents, not what is assumed or inferred because she/he knows what should be there. Many of the processes described in the QA cycle and the competencies mapping activities described above are administrative, rather than academic. It is appropriate that support staff, in advance of the process, undertake the preparation of draft unit mapx, when time permits. It increases their familiarity with course content and enhances the advice that they give to students at the same time. Academic staff will much more readily make alterations to a draft map, based on their knowledge of the field, and engage in discussion about omissions and duplications, when they have the draft documents before them.

Conclusion

The main message to be drawn from this case study is that workforce literacies provide a useful tool for curriculum design, to assist accreditation processes and for ongoing QA. Other academic departments are recommended to consider utilising literacies to assist accreditation and QA activities. The activities described here focus on EH education and course accreditation but they are transferable to other practice based disciplines, such as teaching or nursing, which have industry competency requirements for registration and practice. The processes are relatively easy to get started, and do not require a significant commitment of time above that which is required for routine QA activities.

Once established, the curriculum-literacy unit maps allow academic staff to see at a glance what needs to be done. Redundancies and areas for change can be identified readily, and the maps can be updated whenever a change is made to a unit. The maps also have the potential to enhance communication between the AIEH (and other accrediting bodies) and universities to ensure academics are given specific advice about elements requiring updating in response to legislative or workforce changes.

Acknowledgments

All members of the Department of Health and Environment, School of Public Health, La Trobe University Bendigo participated in the various activities reported here. We thank them for their enthusiasm and commitment to evidenced based curriculum development and ongoing quality activities. Dr Melissa Graham was employed to conduct the original health promotion competency-curriculum mapping in 2003. Ms Marg Kent was employed to assist with a Quality Assurance project for the BPH during 2005 and she assisted with the development of the curriculum-literacy maps.

References

Australian Institute of Environmental Health (AIEH) <http://www.aieh.org.au/index.php> 8 September 2006.

Commonwealth of Australia 1998, *Environmental Health in Australia: Towards a National Strategy*, National Environmental Health Forum, Commonwealth Department of Health and Aged Care, Canberra.

Commonwealth of Australia 1999a, *The National Environmental Health Strategy: An Australian Charter for Environmental Health*, Commonwealth Department of Health and Aged Care, Canberra.

Commonwealth of Australia 1999b, *National Environmental Health Forum: Environmental Health Practitioners, Future Challenges, Future Needs*, Brisbane, 8-9 April.

Commonwealth of Australia 2000a, *Proceedings of the Environmental Health Symposium on Education, Research and Workforce*, Canberra, 17-18 July.

Commonwealth of Australia 2000b, *Environmental Health Risk Assessment Public Consultation* (Draft, April 2000). Environmental Health Section, Department of Health and Aged Care, Canberra.

Greater Bendigo City Council 2006 <http://www.bendigo.vic.gov.au/> 8 September 2006.

Ife, J. 2002, *Community Development: Community-based Alternatives in an Age of Globalisation*, 2nd edn, Pearson Education Australia, French's Forest, NSW.

James, E., Talbot, L. & Kent, M. 2006, 'How an evidence-driven audit cycle model can be used to assist quality assurance in environmental health education', *Environmental Health*, vol. 6, no. 3, pp.52-8.

Lau, W. 2005, *Winds of Change*, Paper presented to the 2005 National Conference of the Australian Institute of Environmental Health, Adelaide, 8-10 November.

La Trobe University Handbook <www.latrobe.edu.au/handbook/bendigo/> 8 September 2006.

Madden, L. & Salmon, A. 1999, 'Public health workforce: Results of a NSW statewide consultation on the development of the national public health workforce', *NSW Public Health Bulletin*, vol. 10, no. 3.

Mendoza, J., Parker, E. & Fresta, J. 1994, 'If the suit doesn't fit why wear it? Competency-based training and health promotion', *Health Promotion Journal of Australia*, vol. 4, no. 2, pp. 9-14.

NSW Health Department 1998, NSW *Consultation on the Development of theNational Public Health Workforce for the National Public Health Partnership*, December 1998, NSW Health.

Peach, H. 2000, *Australia's National Environmental Health Strategy and Workforce Development*, Paper presented at the Environmental Health Symposium, Canberra, July 17-18.

Redman, J. & O'Hara, L. 2003. 'Perceptions of credentialing for health promotion practitioners in Australia', *Health Promotion Journal of Australia*, vol. 14, no. 1, pp. 25-31.

Shilton, T., Howat, P., James, R. & Lower, T. 2001, 'Health promotion development and health promotion workforce competency in Australia', *Health Promotion Journal of Australia*, vol. 12, no. 2, pp. 117-23.

Shilton, T., Lower, T., Howat, P. & James, R. 2003, 'Variations in perceptions of urban and rural health promotion competencies', *Health Promotion Journal of Australia*, vol. 14, no. 1, pp. 15-18.

Talbot, L., Graham, M. & James, E. 2007, 'A role for workplace competencies in evidence based health promotion education', *Promotion and Education*, vol. XIV, no. 1, pp. 28-33.

Correspondence to:
Lyn Talbot
Course Coordinator and Head of Department
Department of Health & Environment
School of Public Health
La Trobe University
PO Box 199
Bendigo, Victoria, 3552
AUSTRALIA
Email: L.Talbot@latrobe.edu.au

Back to TOC

Public Participation in Local Government: A Case Study of Regional Sustainability Monitoring in Western Sydney

Cesidio Parissi

School of Natural Sciences, University of Western Sydney

Sustainability is an important process and objective of society. State of the Environment Reporting at both the local and regional level is an important part of monitoring the wider sustainability project. Legislation and practice emphasises public participation in the context of sustainability monitoring and reporting. The sustainability project has been less than successful in two crucial ways that form a nexus at the local level. First, the effects of sustainability practice at this level have not been sufficiently successful, and second, practitioners have refined the techniques of public participation but, often, with little impact on final decisions. The gap between theory and effective practice seems wide and this paper explores some of that territory. This paper examines a specific case study of this situation in two ways. First, in the context of the development of an alternative model in the preparation of the Western Sydney Regional State of the Environment Report 2000*, and second, and importantly, an exploration of the Report's problematic aftermath. Proposals in this paper to help councils in their path towards sustainability include the deeper participation of the public in the sustainability project within a local council framework and the inclusion of community developed indicators of sustainability in the management plans of councils. An implication of the study amounts to a plea for those in positions of power to share some of that power with others in an attempt to form a community for joint action.*

Key words: *Public Participation; Regional Environment Reports; Sustainability*

The importance of achieving a more sustainable society is emphasised in a growing body of literature (Pezzoli 1997a, b). Global sustainability is broadly understood here as a situation where the interactions between humanity and nature move increasingly towards a situation where the life supporting and enhancing systems improve over time. A large amount of evidence suggests that much of the considerable effort, which sustainability discourse has explored over the past few decades has, on the whole, not achieved its aims (Brown et al. 2005; National Research Council 1999). Not all writers accept that position. Lomborg (2001) suggests that the problems are strongly overstated. Buckingham and Theobold (2003) suggest that the time between the Rio Earth Summit in 1992 and the Johannesburg World Summit on Sustainable Development in 2002 is not long enough to assess whether the Rio policies and programs have been, or can still be, successful.

The position taken in this paper is that due to the threats inherent in a growing list of social, economic and environment problems, there is an increasing need for effective action for sustainability. This position is similar to that taken by the World Resources Institute (WRI), the United Nations Development Programe, the United Nations Environment Programe and the World Bank (WRI 2003). In a recent joint publication, these organisations have concluded that on an absolute level, "Since the Rio Earth Summit in 1992, the capacity of Earth's ecosystems to sustain human well-being has deteriorated in nearly every category measured" (WRI 2003, p. 23).

Thus, although progress has been made in some areas, major shortcomings are manifest. For example, despite the 'success' of a few international agreements such as the 1987 Montreal Protocol, legislation is often not effective, not effectively enforced or is subverted (Burgin 2002; WRI 2003; Yencken 2002). Also, although scientific information is becoming increasingly available, it can ossify in unconsulted volumes on innumerable shelves (Parissi 2002). Further, seemingly worthwhile policies are formulated, but are not put into effect (Crowley & Walker 1999), and engineering solutions that sometimes fix one problem might instigate others (Taplin 1999). We have successfully identified many of the environmental problems, but have, so far, been relatively unsuccessful in identifying sustainable solutions (Costanza & Jorgensen 2002).

Within the sustainability discourse, emphasis is placed on action at the local level, where, in terms of civic governance, citizen and institution most closely meet (Brown 1997; Harris & Chu 2001; Whittaker et al 1999). Here, governance is used as a generic term and means 'forms of decision making'. Further, the rationale for the given emphasis on local action is often presented under the rubric of 'think global, act local' (WRI 2003). A prominent manifestation of this is the globally significant United Nations initiative of Agenda 21, in which Chapter 28 promotes the importance of sustainability action at the local government level (Adams & Hine 1999; Buckingham & Theobold 2003). A key question is: How does this impetus for positioning sustainability at the local level manifest itself in terms of praxis, that is, in the terrain where theory, practice and effect interact?

One useful approach to this question is to examine the role, discourse and outcomes of the practitioners in the field of public participation, for these are the people who work at the 'coalface' of interaction between local councils and their communities. First, what is public participation, and why is it important? Public participation can be understood as "[a process that uses]...a variety of techniques and strategies to enhance ... participation in decision making...in relation to individuals, governments, institutions, and other entities that effect the public interest..." (International Association for Public Participation (IAP2) 2005). Harris and Chu (2001, p. 43), in referring to a World Health Organization publication, suggest that community participation "... provides a means to motivate individuals and communities and organise action". These authors list four reasons for having a participatory process, and, while they are referring to the development of sustainability indicators, this rationale can be applied to sustainability processes in general. The cited advantages of participation are that:

- the community's understanding of local issues is increased;
- a participatory approach can improve the acceptance of programs;
- it can increase the sense of ownership of the process;
- the approach fulfils ethical requirements to work in partnership with communities (Harris & Chu 2001);
- it fulfils the requirements of legislation (DLG 1999).

Despite these apparent benefits, within the literature there is a considerable emphasis on how carefully developed consultative methods are regularly used by facilitators but with less than hoped for effect on project outcomes (Berry, Carson & White 2003; von Braunmuhl & Winterfeld 2005). For example, forums are conducted for various agencies, with the results virtually ignored (Hendriks 2002; Scott 2003) and visioning documents are produced with caring detail and then shelved by local councils (Parissi 2003). Thus, the sustainability project has been, so far, less than a success in two crucial ways that have a nexus at the local level. First, the effects of sustainability practice at this level have not been successful enough. And, second, practitioners have refined the techniques of public participation, but often with little effect on final decisions. The gap between theory and effective practice seems wide and this paper explores some of that territory.

In particular, this paper considers these matters as they are manifested in the process, outcomes and aftermath of the *Western Sydney Regional State of the Environment Report 2000*, hereafter referred to as the Report (Western Sydney Regional Organisation of Councils [WSROC] 2000). The first part consists of a presentation of the process of accumulating data for the Report and its products; the second part derives from a study that this author conducted in 2002 of the aftermath of the Report. The author was not a part of the Report's project team.

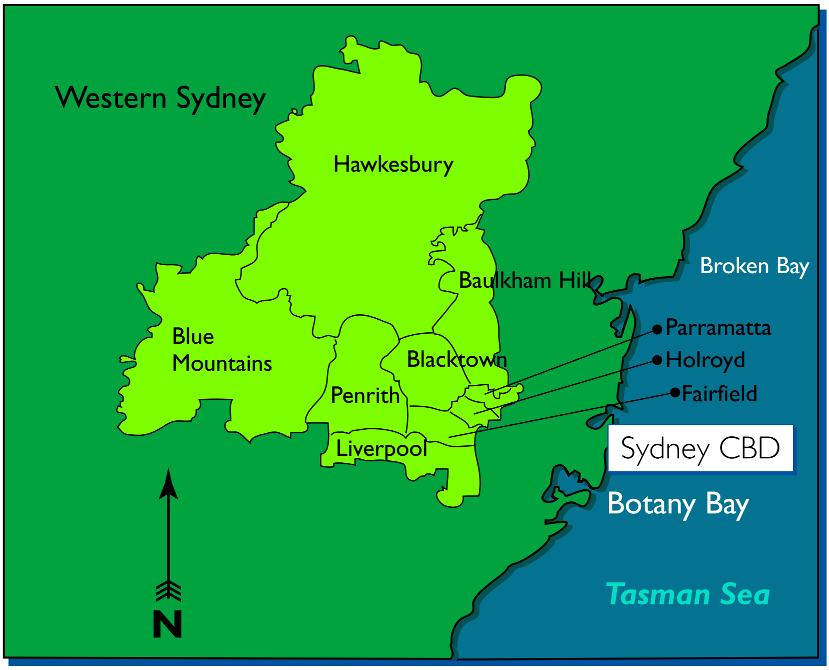
Legislative and Geographic Context

State of the environment reporting began as collections of data that indicated the effects of human impacts on our planet, with the first local government environmental reports in NSW being issued in the early 1980s, but quickly evolved as an outcome of Australia's attendance at the 1992 Rio Earth Summit (Ecologically Sustainable Development Steering Committee [ESDSC] 1992; Powell, Love & Sampson 1999). The New South Wales (NSW) legislature passed the *Local Government Act* in 1993 that required each of its local councils to compile and to issue an annual State of the Environment Report (SoE). That requirement was amended by law in 1997 to issuing a major report each four years and a minor one each other year, to include community input, and to have these reports linked to the Management Plans of the council (Powell et al. 1999). Although the 1997 amendments eased some of the pressure that councils were under since 1993 to produce a major report each year, the SoE requirements were still not accompanied by any additional resources such as funding or training, or an improved theoretical framework (Anderson et al. 1997; Lloyd 1996; Powell et al. 1999).

This legislation included the effects of human actions in terms of social, economic and environmental matters and covered the designated themes of land, air, water, Aboriginal heritage, non-Aboriginal heritage, biodiversity, noise and waste while using the Organisation for Economic Cooperation and Development's Pressure-State-Response (PSR) model of reporting (Powell, Williams & Murphy 2001). This rested on a foundation of Ecologically Sustainable Development (ESD), as enunciated in the Brundtland Report of 1987 (World Commission on Environment and Development [WCED] 1987) and as adopted at the Rio Earth Summit and by all tiers of Australian governments in 1992 (ESDSC 1992). In NSW, ESD is defined as development that meets the needs of the present, without compromising the ability of future generations to meet their own needs (Environment Protection Authority 2000; *Local Government Act* 1993).

In 1999, the nine councils that then voluntarily made up WSROC decided to combine their efforts to produce a regional SoE. This impetus came from an attempt to pool resources and for a more effective approach to meet the new legislative needs. Some reasons stated for employing a regional approach to fulfil requirements of the 1999/2000 reporting period included: achieving greater objectivity by using consultants external to the councils; more effective use of regional agencies; developing new models to reflect new legislative requirements; gaining economies of scale, and developing a standardised approach to regional issues (Brown 2001a). The WSROC councils were Blacktown, Parramatta, Liverpool, Fairfield, Blue Mountains, Holroyd, Hawkesbury, Baulkham Hills and Penrith (Figure 1). WSROC engaged the Regional Integrated Monitoring Centre (RIMC) of

Figure 1: The nine councils that made up the Western Sydney Regional Organisation of Councils in 1999



Source: Western Sydney Regional Organisation of Councils (WSROC) 2000

the University of Western Sydney and the, then, Hawkesbury-Nepean Catchment Management Trust (HNCMT) to compile and produce the Report.

The western Sydney region is principally made up of middle ring areas with a mix of commercial, industrial, rural lands, bushland, and with old settlements and rapidly expanding new suburbs. The WSROC region covered 5760 km^2; had 1,094,066 residents in 1999, which was approximately a quarter of the population of Sydney. It includes council areas that are mostly covered by trees, those that are mostly cleared, and those that are mostly defined by urban development, and other councils that have a mixture of these settlement forms. As an entity, the councils that make up WSROC have an ecological footprint that is 12 times the actual size, that is, it 'consumes' the resources of an area that is 12 times its own geographical size (WSROC 2000).

Preparation and Outcomes of the Report

While they rested within a sustainable development context, SoEs evolved from just being catalogues of human impacts as compiled by scientists, to then being used by environmental managers to address these issues (risk management). Throughout this period they remained static examinations of the past interactions of the human and natural worlds (Brown 2001b; Parissi 2002). Although the Report had a very different trajectory, it needs to be emphasised here that it was deeply imbedded within the above history and practice of local SoE reporting. That is, when SoEs were only seen as a matter for the 'Environment Department' not for the whole of council, and viewed as a static document, not one that was linked directly to strategy or budgeting. Table 1 describes this situation as a summary of the history of SoE reporting in Australia that has its theoretical framework being nudged

Table 1: The complex terrain of sustainability discourse, environmental reporting and State of the Environment Report (SoE) practice in Australia

Category Examined	Time Line		
	1. Up to early 1990s	2. Up to about 1995	3. From about 2000
Theory/Paradigms Three Positions of Practitioners of SD	Systems Maintenance	Systems Change	Systems Shift
Model Employed:	Carson's (1962) *Silent Spring* or biogeochemical model.	OECD's 1993 *Pressure-State-Response* model (OECD 2001a) that followed World Commission on Environment and Development's *Our Common Future* - the 'Brundtland Report' (WCED 1987).	• Wackernagel & Rees' (1996) Ecological Footprint; • AtKisson's (1999) *Compass Index of Sustainability*; • Hamilton & Denniss' (2000) *The Genuine Progress Indicator*; • Brown's (2001a) *Pressure-State-Response-Potential*.
Practice Type of Measurements:	Biogeochemical indicators	Biogeochemical and Social Indicators	Quality of Life / Community Indicators
Function of State of the Environment Reports:	Passive look at the past effects	Act on past effects to remedy the situation	Act for the future using strategic planning to achieve future goals.
Use of SoEs:	For Data Storage	For Risk Management	As a Sustainability Guide
Who Uses / (should use) the SoE:	Environmental Scientists	Environmental Managers	All the Community as a strategic document

Principal sources not cited above: Brown 2001a; Lloyd 1997; Powell et al. 2001. Adapted from Parissi 2002

forward, towards the adoption of a new paradigm as a functioning practice.

Table 1 shows a transition from the early environmental reporting model of 'systems maintenance' where deleterious environmental effects were catalogued, to the 'systems shift model where these past effects were to be rectified, and then to the 'systems change' model where a future oriented set of programs and strategies would be implemented. The WSROC Report attempted to pioneer WSROC councils and communities on the path of the latest stage of the evolution of the theory of SoEs (Brown 2001b). In particular, this evolution was reflected in the framework of the Report when it moved from looking at the past to one of a future orientation by linking the SoE process to council's management plans, that is, to move towards sustainability. Although this was largely achieved in the production of the Report, its implementation by any institution was limited, as discussed below.

Thus, a new type of framework was developed for the Report: the Pressure-State-Response-Potential. The PSRP model added a process of 'Potential' to the previous PSR format. This diagnostic 'Potential' step was intended as the link to put into effect the actions that councils (or regions) needed to take as a result of the previous steps in the report process. The other elements in the model aimed to document the "Pressures on the State of the environment from human activities, and the Responses to those Pressures" (WSROC 2000, p. iv).

A second innovative approach was to incorporate a synthesis of 'multiple knowledges' into the process of the Report. These included the three usually identified areas of 'local knowledge' of the community, the 'specialised knowledge' of the professionals, and the 'strategic knowledge' of decision-makers (Brown 2005). In addition to these three, another was added, that of 'holist knowledge'. The fourth knowledge was "A shared vision of the future, a focus for all stakeholders [which is] area specific, long-term, community oriented" (Brown 2001b, p. 14). The fourth knowledge area was seen by the consultants as vital to shift the regional SoE project into being a future-oriented, sustainability process.

In order to link the scientific data and the policy framework to the community, and thus to provide for more effective outcomes, a three-level structure of consultation was developed. The first of these was an extensive series of community visioning workshops that were held in seven different parts of the WSROC region between December 1999 and May 2000 to formulate a 'Community Vision for 2020' (WSROC 2000). The extent of this public participation was another innovation in terms of SoE reportage in NSW. There were 20 visioning workshops that included 75 organisations (covering community groups; council professionals; local, state and federal elected representatives; lobbyists; industry; farmers; and, educational institutions) and involved 400 participants (Brown 2001b; WSROC 2000).

The first round of consultation produced a number of outcomes, including an agreed vision that "Western Sydney is a place with a strong identity, a deep pride in place, and a widely diverse community learning to live together within a unique natural environment" (WSROC 2000, p. 15). In addition to the vision, the participants chose 600 indicators that any member of the community could use. These were consolidated into 15 Sustainability Indicators that were framed as "goals for the community vision of Western Sydney" (WSROC 2000). Each of these goals was linked to the eight themes that were legislatively required for councils in NSW for SoE reporting.

The second level of consultation had two parts that together added further definition to the community indicators. A representative from each of the primary workshops came together with the consultants, government representatives (local and state) and specialists. An initial task was to synthesise the individual output of each workshop (each workshop produced its own set of 15 goals and indicators) into a single headline set of 15 goals and indicators that represented the whole of the community workshop process. The second part of these workshops was to refine the indicators that the community had produced and to find reliable measures for each of them (WSROC 2000).

The third stage of the workshops was a series of specialised meetings "where Council SoE writers and environmental specialists established measures, and designed tables, graphs and maps to convey the state of the eight environmental themes and the potential for achieving the community's preferred future" (WSROC 2000, p. 15). The final aspect of the regional SoE project, which was a part of the consultant's brief, was the compilation and production of the physical outcomes of the public participation process: a 228 page book; an interactive CD-ROM; a website; and a summary document (available from http//www.wsroc.com.au/report/report/print.htm). In addition, the brief required the production of a review document as a companion to the Report (Brown 2001b). The main components of the final Report consisted of two introductory chapters, one chapter relating to the outcomes of the workshops, eight chapters that apply the outcomes of the workshops to the SoE themes (as designated by legislation), and a final chapter on recommendations (WSROC 2000).

In order to give a feeling for, and hopefully a more accurate account of how the public participation process manifested in the recorded outcomes, the following are three examples, out of 15, of the community-developed sustainability goals and associated indicators for Western Sydney. One example was selected from each of the "environment", "social" and "economic" domains. The first is entitled "Natural Environmental Heritage". The sustainability goal that comes from this is the "regeneration towards an ideal of at least 15% of the original types of Western Sydney bushland". The agreed indicator for this goal is the "area and condition of the remaining locally native bushland as compared to the idealised goal of at least 15% of the original bushland at the time of first settlement [around the 1790s] as described by the [NSW] National Parks and Wildlife Service" (WSROC 2000, p. 17). The links to the future (the 'Potential') were described in three courses of action:

- For the community to: "Become familiar with the protected and endangered bushland areas near to you and work with government agencies and local bushland groups to safeguard and increase the current levels"
- For Council to: "Acknowledge the community goal of at least 15% of the original representative bushland communities in principle, while setting locally appropriate goals in Council's SoE implementation strategies"
- By other organisations: "State and Federal governments and industry [to] support this goal in their plans and strategies" (WSROC 2000, pp. 17-19).

This community goal was aligned with the legislated themes for council SoEs and their subsequent action in the areas of land, air, water, biodiversity, waste and heritage (WSROC 2000, p. 14).

The second example comes from the social domain, 'Celebration of Whole of Community'. The associated sustainability goal states that 'the diverse Western Sydney community feels comfortable to celebrate itself'. The indicator for that community goal is that there are "Annual increases in the number and attendance at festivals actively involving all Western Sydney citizens". Action that attends this goal is for the community, the council, and for state and federal agencies to "Put multicultural festivals in your diary [and to] assist at one and attend at least two a year" (WSROC 2000, p. 22). This was stated to encompass the themes of land and heritage (WSROC 2000, p. 14).

The third example is derived from economic concerns and is expressed as, 'Localised Industry'. The sustainability goal states that 'Western Sydney is clean, green - and local'. Its indicator describes a situation for the region with "Upward trends in local employment in Information Technology and Environmental industries" (WSROC 2000, p. 48). The action that can accompany this goal and indicator is by:

- The "community [encouraging] clean, green and local industries including Environmental industries (environmental management, protection, monitoring, consulting etc) and Information Technology, the new economy
- By council [seeking] partnerships with local industry; set up an Industry Audit program to encourage cleaner production and environmental protection" (WSROC 2000, p. 48).

The related environmental themes that are associated with the community goal of 'Localised Industry' are land, biodiversity and heritage (WSROC 2000, p. 14).

An Assessment of the Outcomes and Aftermath of the Report

It can be concluded that the Report was a success; that all the objectives of the consultants had been fulfilled. At the very least it is difficult to argue against the following facts: the first Australian regional SoE report that was based on sustainability principles had been produced, and it came out in all the required formats, and on time. Further, the degree of public participation that had been implemented was unusually extensive in this context, if not unique, in terms of breadth of consultation and the quality and range of its output. Also of significance is the fact that an immense amount of data from each of the nine participating councils and from a number of other agencies at both state and federal level was successfully collated and then aligned with the 15 community-generated sustainability goals and indicators. This was then linked to the appropriate strategies, policy suggestions and programs that were aimed at implementing the visions and goals of the workshops to the actions of the WSROC councils (WSROC 2000).

Another way to assess the project is in terms of Brown's (2005) knowledge areas described above. Through that lens, three basic points can be made about the outcomes of the Report process. The community in using its local knowledge was able to formulate a vision for the Western Sydney region. The constituent councils were able to agree on appropriate actions in response to the community's vision, and thus manifested strategic knowledge. The experts, who consisted of the consultants and a large array from other organisations, found the appropriate data sources and developed the applicable measures for the indicators that were created through the use of their specialist knowledge. The Report represented the input of all the participants, from residents to stakeholders, as a wholistic conclusion of the process. One might again conclude that the WSROC Report process was an outstanding success and, at least in the ways described above, it certainly was.

In addition to the above, however, there is another way to assess the Report, namely, an exploration of what happened to it once it was published. Was it effectively used, why or why not, and in what ways, if any? In order to answer that question, I conducted a study in 2002, about 18 months after the Report itself was issued (Parissi 2002). That study centred on research conducted with eight of the nine councils that formed WSROC at the time the Report was compiled and, although much of that data cannot be detailed here due to lack of space, it will be the primary source of information for the discussion that follows.

The methodology for the study was broadly within the domain of ethnography, that is, an investigation that describes and interprets a social group in its natural setting (Creswell 1998). The study also borrowed from the grounded theory approach, that is, one that in general begins with an open-ended inquiry area that is explored, rather than a hypothesis or theory that is tested by a study of a case (Creswell 1998). However, the approach taken was closer to the post-positivist 'constructivist grounded theory' of Charmaz (2000) where the 'researcher' and the 'researched' interact subjectively, and both are given voice in the study. The grounded theory approach was also modified in that the strict coding structure of the technique's originators Glaser and Strauss (1967) was not employed and the more flexible approach of thematic analysis was used (Blaxter, Hughes & Tight 1996).

The methods that were employed for that study were document analysis, semi-structured interviews with key informants and the use of a survey instrument. The interview and survey were conducted during the same session that lasted for one to two hours with each of the 16 key informants who either managed, carried out the project, or who occupied the positions of those who originally did so. Fourteen of the 16 interviewees represented almost all of the participants in the project who were still in their positions at the time of the study; the other two informants occupied, at the time of the study, the positions of the original actors. Ten of the informants were from eight of nine involved councils and, except for one individual, those informants were involved in the Report's steering committee; the relevant person from the ninth council declined invitations to participate in the study. The other key informants comprised six people from the expert group which compiled the Report and who came from the Regional Integrated Monitoring Centre, the Hawkesbury-Nepean Catchment Management Trust and WSROC.

Each interviewee was asked a total of 13 questions, which were a mixture of closed and open questions, with each question commonly being a beginning point for discussion. As a final task of the session, participants were also asked to respond on a Likert-type five-point scale (Robson 1993) to assess how the recommendations of the Report had fared; this task constituted question thirteen. For that final question, in addition to filling out the survey sheet, respondents were also asked to write any additional comments on the form. A hand written record was taken during the interview session. All interviewees were guaranteed anonymity.

What happened to the Report?

In broad terms, 50% of the council respondents viewed the Report in a positive, if passive, way, making comments like, "It was a good experiment", "It was a benchmark report". Others in this group suggested that the Report was useful as a reference document for students and the general public; one such informant stated that the council did the usual thing and placed "a copy of the SoE in the public library". Still other participants in the study suggested that their councils had gained significant insights from the approaches used in compiling the Report, these informants came from two out of eight (25%) of the respondent councils. One stated, "We have undertaken a review of the indicators, included some of the aims of the report, got council thinking about the community indicators approach". Another said "Yes, we've used the indicators, begun to involve the community and have used the PSRP model in the [local] SoE".

Another set of opinions, as given by respondents to the study, has 50% of council participants in the study giving only negative answers to three questions; these will be given and then followed by a typical response. One question asked, "What do you think of the report?", an interviewee stated, "Only about 5% of the report was of use to us for our [local] SoE". A second question was "Has the local SoE for your council been modified by the experience of producing a regional report?", a typical comment was "The council did not have sufficient resources to allocate to the task and our next report was in the old style". The third question asked, "How well do you think that your council has incorporated the recommendations of the report into its Management Plans?". Responses to this question included, "The report is mentioned in the management plans but there are no linkages for effective action" and, "No, not at all, councillors don't want to know this sort of stuff".

So, one is left to ponder why such a significant, well-conducted and ground-breaking document was not taken up more, and in more ways, than occurred. Some of the reasons for this outcome were of a practical nature, such as those referred to above by Lloyd (1996) and Anderson et al (1997) - greater demands on councils, but no additional resources were given. For example, in regard to the regional Report that needed to consolidate data, councils did not have compatible Geographic Information Systems, compatible data sets, or agreed methods for data collection. One respondent summarised the data issue in this way:

> *We can have two councils along or across from the same stream, but we don't necessarily use the same sampling techniques, the same instruments,*

the same methods, or units of measurement and, if we get all of that right, we can still do it at different times of year or in different years.

In addition, there was an underdeveloped practical framework, as described by respondents for both local and regional aspects of the Report. In terms of a local report, “It needed to be considered a corporate document, not an environment or Environmental Health document”; and in terms of regional reporting, “How can you have a Regional SoE without a regional environmental framework to integrate it into?”. This framework could have been WSROC, Team West, the Office of Western Sydney or one or more State government departments. In the end, the only organisations that could have taken effective carriage of the Report were the individual councils which participated in its production, and this did not facilitate a regional approach.

Perhaps the matter that was more important than the above practical issues had to do with the vexed question of the active involvement of the community in developing what was traditionally viewed as a council document. While one or two councils appreciated the new approach with regard to community involvement, most did not know how to handle it. For example, respondents made the following comments, “The academics [that is, the consultants] wanted community knowledge, the councils wanted scientific knowledge”. “The consultants spent 80% of their time on the visioning exercise and 20% on data management, it should have been the reverse”. It was reported by two respondents that one particularly belligerent participant in the Report’s steering committee refused to accept the notion of community orientated SoEs. In one particularly heated planning meeting, that individual was reported as having “shouted at the consultants in arguing against the idea of a community document”. That person refused to accept the idea of a community engagement model for the Report. Even the requirement of the new legislation seems not to have provoked a sense of the need for a new approach, instead, among a significant proportion of the participating councils, it seems to have produced a deal of anxiety.

With few exceptions, the council participants in the study showed little appreciation for the extent and quality of the community consultation aspects of the Report. The following points can be made. SoE reports have relatively low status within many councils and are still regarded as simply collections of scientific data, rather than as being policy and budget oriented or as being a source of community activity and change. This was discussed as the ‘Systems Maintenance’ or, perhaps, the ‘Systems Change’ stage of the evolution of reportage that was dealt with in Table 1, above. The proponents of the Report were trying to advance the reporting framework towards a ‘Systems Shift’ model of sustainability. For those who inhabit the older mind set, the involvement of non-professionals, that is the community, seems to be rather confronting, as suggested by the following statement from an interviewee: “The usual way that councils consult the ratepayers is to place a copy of the SoE in the public library”. Another respondent, who was referring to SoE reports, stated that they were, “Done by juniors as a data gathering and public relations exercise”. This statement does not leave much room for SoEs to be considered as a lever for effective community engagement.

Conclusion and Recommendations

In order for effective progress of the sustainability agenda, especially with regard to the field of environmental management and, in particular, environmental and sustainability monitoring, an effective nexus needs to be developed between state of the environment reportage and public participation. If sustainability is to be considered a matter of global integrity that combines society, the economy and the environment, then the engagement of the community in SoE reporting could well assist with this agenda. Further progress of the approach that was taken in formulating and executing the WSROC regional Report, could see the participants, that is, the 400 residents, stakeholders and the councils combine as active change-facilitators to promote a range of actions, as given in the Report. Further, the participating councils could evolve their internal processes by deepening the incorporation of SoE reporting into their Management, Corporate and Strategic Plans.

Acknowledgments

Thanks go to my patient supervisor, Professor Valerie A. Brown, AO who guided me through the Honours year study that formed the basis for this research. Also, my deep thanks go to all the participants from the various organisations who freely gave of their time for my interviews.

References

Adams, G. & Hine, M. 1999, 'Local environmental policy making in Australia', in *Australian Environment Policy 2: Studies in Decline and Devolution*, eds K.J. Walker and K. Crowley, UNSW Press, Kensington, NSW.

Anderson, E., Simpson, R., Kitching, R., Conacher, A., Ingle Smith, D., Morrison, J., West, R., Buckley, R., Dovers, S. & Laird, P. 1997, 'State of the environment 1996: Review of the National State of the Environment Report', *Australian Journal of Environmental Management*, vol. 4, no. 2, pp. 157-84.

Berry, T., Carson, L. & White, S. 2003, *We are all Stakeholders: Participatory Decision-making and Corporate Sustainability*, paper presented at the Corporate Social Responsibility and Environment Conference, 30 June-2 July, University of Leeds.

Blaxter, L., Hughes, C. & Tight, M. 1996, *How to Research*, Open University Press, Buckingham.

Brown, V.A. 1997, 'Managing change: The new manager', in *Managing for Local Sustainability: Policy, Problem-solving, Practice and Place*, ed. V.A. Brown, National Office of Local Government, Canberra.

Brown, V.A. 2001a, *Producing a Regional State of the Environment Report, Companion Report to the Western Sydney Regional State of the Environment Report 2000*, Regional Integrated Monitoring Centre, Richmond, New South Wales. <http://www.uws.edu.au/research/rimc> 20 March 2003.

Brown, V.A. 2001b, 'Monitoring changing environments in environmental health', *Environmental Health*, vol. 1, no. 1, pp. 21-34.

Brown, V.A., Grootjans, J., Richie, J., Townsend, M. & Verrinder, G. eds 2005, *Sustainability and Health: Supporting Global Ecological Integrity in Public Health*, Allen & Unwin, Sydney.

Brown, V.A. 2005, 'Knowing: Linking the knowledge cultures of sustainability and health', in *Sustainability and Health: Supporting Global Ecological Integrity in Public Health*, eds V.A. Brown, J. Grootjans, J. Ritchie, M. Townsend & G. Verrinder, Allen & Unwin, Sydney.

Buckingham, S. & Theobold, K. eds 2003, *Local Environmental Sustainability*, Woodhead Publishing, Cambridge.

Burgin, S. 2002, 'Tragic consequences for conservation of mis-defining the term "community"', in *A Clash of Paradigms: Community and Research-based Conservation*, eds D. Lunney, C. Dickman & S. Burgin, Royal Zoological Society of New South Wales, Sydney.

Carson, R. 1962, *The Silent Spring*, Houghton Miffin, Boston.

Charmaz, K. 2000, 'Grounded theory: Objectivist and constructivist methods', in *Handbook of Qualitative Research*, eds N.K. Denzin & Y.S. Lincoln, Sage Publications, Thousand Oaks, Calif.

Costanza, R. & Jorgensen, S.E. eds 2002, *Understanding and Solving Environmental Problems in the 21st Century: Towards a New, Integrated Hard Problem Science*, Elsevier, Oxford.

Crowley, K. & Walker, K.J. 1999, 'Introduction', in *Australian Environment Policy 2: Studies in Decline and Devolution*, eds K.J. Walker and K. Crowley, UNSW Press, Kensington, NSW.

Creswell, J.W. 1998, *Qualitative Inquiry and Research Design: Choosing among Five Traditions*, Sage Publications, Thousand Oaks, Calif.

Department of Local Government 1999, *Environmental Guidelines - State of the Environment Reporting by Local Government - Promoting Ecologically Sustainable Development*, Department of Local Government, Sydney. <http://www.dlg.nsw.gov.au/Files/Information/soe99.pdf > 30 May 2005.

Ecologically Sustainable Development Steering Committee (ESDSC) 1992, *National Strategy for Ecologically Sustainable Development*, Commonwealth of Australia for Council of Australian Governments (COAG), Canberra. <http://www.environment.gov.au/esd/national/nsesd/strategy/intro.html#Principles> 3 April 2007.

Environment Protection Authority 2000, *New South Wales State of the Environment 2000*, Environment Protection Authority, Sydney.

Glaser, B.G. & Strauss, A.L. 1967, *The Discovery of Grounded Theory: Strategies for Qualitative Research*, Aldine de Gruyter, Chicago.

Hamilton, C. & Denniss, R. 2000, *Tracking Well-being in Australia*, The Australia Institute, Canberra. <http://www.tai.org.au> 10 May 2005.

Harris, N. & Chu, C. 2001, 'The development of indicators of sustainability at the local level: Methodology and key issues'. *Environmental Health*, vol. 1, no. 2, pp. 39-52.

Hendriks, C. 2002, 'Institutions of deliberative democratic processes and interest groups: Roles, tensions and incentives', *Australian Journal of Public Administration*, vol. 61, no. 1, pp. 64-75.

International Association for Public Participation (IAP2) 2005 <http://www.communitybuilders.nsw.gov.au/builder/participation/res_iap2.htm> 16 May 2005.

Local Government Act 1993.

Lloyd, B. 1996, 'State of environment reporting in Australia: A review', *Australian Journal of Environmental Management*, vol. 3, no. 3, pp. 151-62.

Lomborg, B. 2001, *The Skeptical Environmentalist: Measuring the Real State of the World*, Cambridge University Press, Cambridge.

National Research Council 1999, *Our Common Journey, a Transition Toward Sustainability*, National Academy Press, Washington.

Parissi, C. 2002, Complexity, confusion, conflict and concern in sustainability discourse and praxis: Outcomes from the Western Sydney Regional State of the Environment Report 2000, Honours Thesis, School of Environment and Agriculture, University of Western Sydney, Sydney.

Parissi, C. 2003, 'Lessons from local sustainability monitoring: outcomes and aftermath of the Western Sydney Regional State of the Environment Report 2000', *Environmental Health*, vol. 3, no. 3, pp. 54-66.

Pezzoli, K. 1997a, 'Sustainable development: Transdisciplinary overview of the literature', *Journal of Environmental Planning and Management*, vol. 40, no. 5, pp. 549-74.

Pezzoli, K. 1997b, 'Sustainable development literature: A transdisciplinary bibliography', *Journal of Environmental Planning and Management*, vol. 40, no. 5, pp. 575-601.

Powell, J., Love, D. & Sampson, K. 1999, 'Introduction', in *State of the Environment Reporting Manual*, ed. J. Powell, Hawkesbury-Nepean Catchment Management Trust, Windsor, NSW.

Powell, J., Williams, R. & Murphy, A. 2001, *Preparing a Local State of the Environment Report: A Guideline*, Department of Land and Water Conservation, Windsor, NSW.

Robson, C. 1993, *Real World Research: A Resource for Social Scientists and Practitioner-Researchers*, Blackwell, Oxford.

Scott, J.E. 2003, *Integrating sustainability provisions into contemporary decision making*, PhD Thesis, School of Environment and Agriculture, University of Western Sydney, Richmond, Australia.

Taplin, R.E. 1999, 'Sydney: Sustainable city?', in *Australian Environment Policy 2: Studies in Decline and Devolution*, eds K.J. Walker and K. Crowley, UNSW Press, Kensington, NSW.

von Braunmuhl, C. & von Winterfeld, U. 2005, *Sustainable Governance: Reclaiming the Political Sphere. Reflections on Sustainability, Globalisation and Democracy*, Wuppertal Institute for Climate, Environment and Energy, Wuppertal, Germany. <www.wupperinst.org/globalisation> 10 May 2005.

Wackernagel, M. & Rees, W. 1996, *Our Ecological Footprint: Reducing the Human Impact on the Earth*, New Society Publishers, Gabriola Island, Canada.

Western Sydney Regional Organisation of Councils (WCROC) 2000, *Western Sydney Regional State of the Environment Report 2000*, Western Sydney Regional Organisation of Councils, Blacktown, Australia.

Whittaker, S., O'Rourke, A., Banfield, K., Griffiths, E. & Woodcock, S. 1999, *Policy Integration, Ecologically Sustainable Development (ESD) and Local Agenda 21 - Councils in NSW*, Institute for Sustainable Futures, Department of Local Government and participating councils, Sydney. <http:www.isf.uts.edu.au/whatwedo/ARP.pdf> 14 April 2005.

World Commission on Environment and Development (WCED) 1987, *Our Common Future*, Oxford University Press, Oxford.

World Resources Institute (WRI) 2003, *World Resources 2002-2004*, World Resources Institute, Washington.

Yencken, D. 2002, 'Governance for sustainability', *Australian Journal of Public Administration*, vol. 61, no. 2, pp. 78-89.

Correspondence to:
Cesidio Parissi
School of Natural Sciences
University of Western Sydney, Hawkesbury Campus
Building K8, Locked Bag 1797
Penrith South DC, NSW, 1797
AUSTRALIA
Email: c.parissi@uws.edu.au

Back to TOC

Noise Provisions and At-risk Children in New Zealand Early Childhood Centres

Stuart J. McLaren

Institute of Food Nutrition and Human Health, Massey University, Wellington

As part of a complete revision of the New Zealand legislation, noise in early childhood centres has been identified in the initial consultation process as a major concern. Two legal frameworks exist in many countries including New Zealand for the control and management of noise, and both have been considered as options for the noise provisions in new draft legislation. The first framework involves the Setting of Prescribed Sound Pressure Level Limits *with licensees required to ensure that noise generated in their centre does not exceed these limits. The implementation of this framework would require a considerable increase in resources for monitoring and enforcement. The second framework known as the* All Practicable Steps *model completely dispenses with prescribed limits and would require licensees to take all practicable steps to control noise in their centres. This approach has significant advantages over the former framework as it could be implemented with current resources and staff, whereas the former could not. This framework also allows for specific needs of at-risk children to be addressed. A new draft law with increased coverage of noise has been proposed in New Zealand. The paper discusses the rationale behind the legal framework chosen by the Ministry of Education to regulate noise with the proposed criteria for controlling noise presented, evaluated and discussed in detail.*

Key words: *At-risk Children; Noise; Legislation for Noise; Early Childhood Education*

Noise has been identified as a major international issue in education. In 1999, the General Assembly of the International Institute of Noise Control Engineers (I-INCE) on advice from the World Health Organization (WHO), implemented a Technical Initiative (TSG#4) to investigate noise and reverberation control in schoolrooms around the world and to recommend suitable criteria and rules to follow (Karabiber, Luban & Sutherland 2002). Contributions from member countries have been received and a final report is now under preparation.

In 2002, at a meeting of the I-INCE Classroom Acoustics Technical Committee in Detroit, New Zealand representatives sought clarification in relation to early childhood education. The technical committee agreed that early childhood education was to be included and that was always the intention. As New Zealand is one of the few countries, to date, to undertake dedicated studies of noise and acoustics in early childhood education, its contributions to the Technical Initiative remain unique. In New Zealand, noise in early education has been a pressing issue largely due to concerns by teachers and the publicity surrounding the issues of noise in early education centres in New Zealand.

Regulation 22 of the *Education (Early Childhood Centres) Regulations 1998* states:

> *The licensee of a licensed centre must ensure that every room in the centre that is used by children has, to the satisfaction of the Secretary, adequate natural or artificial lighting, adequate ventilation, acoustics that ensure that noise is kept at a reasonable level, and adequate heating.*

The current Regulations do not define what is considered to be a reasonable (or unreasonable) level of noise.

Legal and practical uncertainly exists when criteria are defined as meeting the satisfaction of 'the Secretary' if the Secretary (of Education) has not clearly documented what outcomes will meet his satisfaction. There are some noises intruding from outside the centre that would be completely outside the control of early childhood centres or governing bodies. Construction sites with activities such as pile driving and jack hammering can be noisy, disturbing and distressing for some children if noise from these activities is not properly controlled. The *Resource Management Act 1991* as effects-based legislation has adequate provisions to address the impact on such sensitive activities as a childcare centre. This is providing that those enforcing this legislation give due regard to the sensitive nature of early childhood centres and the likely presence of special needs children mainstreamed in these facilities. As the New Zealand Standard for Construction Noise (NZS 6803:1999) is used extensively in these cases to set regulatory controls under the *Resource Management Act 1991*, a recommendation to amend the standard to highlight issues surrounding early childhood centres is one approach that can be pursued. It is equally important for early childhood centre management and staff to ensure that they actively participate in the consultation process and make submissions on notifiable consents for noisy activities that are going to affect the children in their care. This would allow appropriate conditions to be considered for such operations.

At-risk Children

Regulation 22 of the Education (Early Childhood Centres) Regulations fails to address the effects of noise on special needs children. A wide range of children with hearing and auditory processing difficulties is well known to be adversely affected by noise. These include those experiencing hearing impairment, speech and communication disorders, Attention Deficit Hyperactivity Disorder, Developmental Delay, Central Auditory Processing Disorders and Sensory Integration Dysfunction. A study by McLaren (2005) suggested that children on the Autistic Spectrum and a subset of gifted children who experience Sensory Integration (Modulated) Dysfunction, could be among the most at-risk groups due to their often extreme sensitivities to noise. While the issues of noise with these children is well known among the specialists and teachers who work with them and their parents, their problems are otherwise not widely known or recognised. The following noises or conditions are often perceived as intense in these children (McLaren 2005; Shields 1998):

- sudden unexpected noises such as barking dogs or a baby crying;
- high pitched continual noises such as mechanical fans, hand dryers, vacuum cleaners, lawn mowers and sirens;
- confusing, multiple or complex sounds such as crowd noise in shopping malls or school classrooms;
- excessive reverberation.

The New Zealand Ministry of Education officials sought advice from the author as to how noise could be regulated in early childhood education (McLaren & Dickinson 2005a). In considering the options available, existing legal precedents were examined, resource requirements considered, and the effects on children in general reviewed with special consideration given to the most at-risk children.

The aim of this paper is to present the current status and issues surrounding noise levels in early childhood, the rationale in setting the criteria to control noise, and to present the draft criteria to control noise for discussion and evaluation.

Current Status and Issues

The last few decades have witnessed major changes and development of innovative teaching practice in early education. Increased noise is perhaps a consequence of the interactive and inclusive approach along with former design criteria, which put an emphasis on hygiene with easily cleanable surfaces. This resulted in hard reflective acoustic surfaces giving excessively long reverberation times. In addition, the conversion of typical domestic dwellings to childcare centres rather than purpose built centres has not involved acoustical treatment as little practical information or guidelines were available.

A major study of noise and acoustics in early education centres has found that noise issues can be divided into the following broad categories (McLaren 2007):

- noise transmitted through or reflected by the building structure;
- noise generated as part of the centre activities
  - noise from children themselves (while engaged in play, when distressed and so on)
  - noise from the use of equipment, fittings, toys, hi-fi, musical instruments and so on;
- noise intrusion from activities outside the centre (over which the centre often has little or no control);
- protection and rights of special needs children known to be adversely affected by noise who are mainstreamed in early childhood centres. This includes children with middle ear infections, hearing impairment, auditory processing disabilities and sensory integration problems;
- lack of quiet spaces;
- excessively noisy fire alarms.

Noise transmitted through or reflected by the building structure

The building must be so designed and constructed that it will attenuate any excessive outside noise to a level that inside will not be intrusive to learning. Children usually do not have the skills to process words lost in noise.

Management of noise generated as part of centre activities

There is precedent for two options in a legislative framework.

1. Setting of sound pressure level standards

In this prescriptive approach, sound pressure level criteria using appropriate noise descriptors are established and all centres would have to take reasonable steps to comply with the criteria. This would include A-frequency weighted time-average level limits over specified times in decibels ($L_{\text{Aeq t}}$ dB). To implement this strategy, considerably more resources would be needed than are currently in use. If sound pressure level limits are to be established, it would mean that sound pressure level measuring equipment would be required to assess compliance, along with officers competent in noise measurement techniques. In addition to the purchase of equipment, there are ongoing maintenance costs and regular calibration of the equipment.

One of the most difficult obstacles to adopting this approach is the lack of an appropriate standard for measurement and assessment. In developing a standard, the following would have to be considered:

- Are sound pressure levels to be measured using fixed sound level meters mounted in such a way to obtain representative samples while not obstructing the free flow of movement around the centre? This would usually mean the use of a microphone on an extension cable from the sound level meter and suspended from the ceiling, beam or other such structure in the middle of the teaching space to minimise reflections. In theory, sound should be measured in the hearing zone (height of the children and teachers' ears), but practicalities preclude this option due to the obstruction of movement and the possibility of damage and interference from tampering and so on. The microphone would, therefore, have to be set at a height above the normal hearing zone.

- Are individual personal sound exposure measurements to be carried out on staff and children? Studies by McLaren and Dickinson (2005) have trialed the recently introduced noise doseBadges on staff and children in early childhood centres. Grebennikov (2006) also carried out a study on preschool teacher exposure to noise using noise doseBadges. While the use of this equipment has given valuable information over the levels of personal sound exposure received by children, there is a considerable amount of preparation required including informed consent of parents to fit these devices to the clothing of their children. Depending on the activities of children, results can vary greatly.

- Accounting for variables such as weather will need consideration. Weather can have an effect on sound pressure levels. During fine weather, children are likely to spend considerable time in outdoor play areas, while inclement weather will confine children indoors.

- Sound pressure levels do not take account of the nuisance value of particular noises. Some sounds do not need to be loud (high sound pressure levels) to be disturbing. Sounds such as sirens, whistles, barking dogs and sharp impact type sounds can be disturbing. Depending on the frequency characteristics, some sounds will interfere and mask speech far more than others at the same sound pressure levels.

- How will the special needs of children adversely affected by noise be addressed? A recent study by McLaren (2005) identified children experiencing sensory integration dysfunction as one of the high-risk groups. Children with autism and Asperger's Syndrome are well known to have sensory integration problems and are often distressed by noise. A subgroup of gifted children is also known to experience this condition.

The main advantage with this approach is that it will give a national standard with which all must comply. It would, however, take a considerable level of consultation to arrive at a consensus over what criteria would be ideal in order to incorporate the large variety of early childhood facilities into such a one-size-fits-all standardised approach. The other main concern is that enforcement would have to be carried out by sound level measurement against the criteria. As enforcement obviously cannot be done in secret, it would be natural for centre staff to manipulate activities and sessions to minimise noise when monitoring was occurring. This would not give an accurate assessment of the situation. It might also be detrimental if certain beneficial activities were curtailed for fear of exceeding a prescribed limit.

2. *All Practicable Steps* model

In the framework of the *All Practicable Steps* model sound pressure level criteria are completely dispensed with and instead the focus is on outcomes with staff to identify noise issues within their centres and then formulate a plan to manage these.

Rather than prescribing sound pressure level criteria, the outcomes to be achieved by controlling noise need to be identified and built into the criteria. In addressing this we need to consider the negative aspects that noise is likely to have on the children and teachers. Some of these are:

- hearing damage to the children if personal noise exposure is excessive;
- interference with speech and communication. This can degrade the dissemination of information and enhancement of socialisation skills;
- damage to teachers' hearing if sound pressure levels exceed the internationally accepted occupational criteria (as defined in the New Zealand Health and Safety in Employment Regulations 1995) of:
  - An A-weighted time-average level of 85 dB over an 8-hour working day or equivalent. That is a maximum of 1.0 pascal squared hour in acoustical terms or 100% dose ($L_{\text{A eq 8 hours}}$ = 85 dB).
  - A Peak Level (Unweighted) of no more than 140 dB (L_{peak} =140 dB).
- voice strain of teachers from having to raise voices. This is most likely to affect those with softer voices who have to raise their voices to be heard over the noise made by children and their activities;
- the effects of noise on special needs children known to be adversely affected by noise. These include those experiencing a wide range of medical conditions and disorders such as:
  - hearing impairment
  - Otitis Media with Effusion
  - Down Syndrome
  - Central Auditory Processing Disorder
  - Autistic Spectrum Disorders (Autism and Asperger's Syndrome)
  - speech and communication disorders
  - developmental delay
  - a subset of gifted children

Unlike the alternative framework of setting sound pressure level criteria, the *All Practicable Steps* model can be implemented with current resources and structures as it is based on subjective judgments to meet a predetermined set of goals or outcomes. Requiring noise to be kept to a level that enables normal speech and communication to occur is one such goal that can be considered. The interference with sleep is an important issue if babies and children are sleeping. Controlling noise levels which distress or harm special needs children is another important outcome or goal in centres where these children are present.

Unlike the approach of the setting of sound level criteria, this is a far more subjective interpretation, which might seem a disadvantage. The *All Practicable Steps* model can, however, be far more responsive to individual characteristics of centres and their receiving environments, which obviously includes those individuals most seriously affected by noise. The requirements could, therefore, be quite different for a centre in which special needs children adversely affected by noise are present against one where there are no such children enrolled.

Other Physical Considerations or Concerns

One of the most important characteristics in the physical learning environment is good acoustical conditions. These include the minimisation of intrusion by external noise generated outside the centre, along with control of reverberation time. At present there is no requirement to provide good acoustical conditions in school classrooms and early childhood education centres. Careful consideration of noise issues should be made when considering a site or location for the establishment of a childcare centre in areas of high background noise, such as placement next to motorways, busy airports, heavy noisy industries and busy railway movements. A study by McLaren and Dickinson (2005b) assessed personal noise exposure levels of children as they walked along busy inner city streets and found A-frequency weighted time average levels could be in the range of 85 dB for the duration of the walking excursion ($L_{\mathrm{Aeq}\ t}$ = 85 dB). This finding alone adds caution to the establishment of early childhood centres in areas of excessive background noise without due consideration of how the effects of such an environment is going to be effectively managed. Such considerations must be addressed in the planning stages. Many inner city childcare centres are located in areas of acceptable background noise levels, but these will generally be located away from the frontage of busy streets or set back in the grounds of a church or other such institutions.

Acoustical quality

Reverberation time is one of the most important acoustical factors to consider in the construction or refurbishment of any learning space. The current standard requires a reverberation time of 0.4-0.6 seconds. (Australian and New Zealand Standard - A/NZS 2107:2000). A recent study showed that a number of centres will not meet these criteria (McLaren 2007). In buildings with high levels of reverberation such as gymnasiums and large traditional (gothic-style) churches, the degradation of speech and communication by excessive reverberation is well demonstrated. A review of the New Zealand Building Code is in progress by the New Zealand Department of Building and Housing and it is understood rules for new classrooms will be incorporated. This would require an appropriate acoustical design for all new school classrooms and preschool learning spaces as part of the building consent process. The new building code, however, if adopted, would not affect existing facilities. It would be up to the Ministry of Education to implement retroactive measures for existing classrooms and learning spaces.

Soundfield amplification technology

Sound field systems to enhance signal-to -noise ratios have often proved an effective tool to assist learning in school settings. A number of studies in the use of sound field technology have found positive outcomes with increased attention to tasks, a higher level of performance against set criteria, an improvement in behaviour and benefits for special needs children (Bennetts & Flynn 2002; Flexer 1997; Palmer 1998). Sound field systems have not been extensively used in New Zealand mainstream early childhood education. More work and studies on the use and effectiveness of sound field systems in New Zealand Early Childhood Education Centres are certainly warranted.

Lack of quiet spaces

Few early childhood centres in New Zealand have dedicated quiet spaces, which are physically separated by solid full height partitions from the other activities. This was identified as a serious fault in the mainstreaming of special needs children who often need one-to-one instruction from teachers, education support workers, speech language therapists and other specialists. In addition, children known to have extreme sensitivities to noise need quiet spaces to retreat to when they are overwhelmed by excessive auditory stimulation. Often no such spaces are available and teachers' office spaces have had to be used. Regional Public Health (2001b) has recommended the establishment of quiet spaces for children in early education.

Excessively loud fire alarms

One issue identified in a number of centres to cause distress to many children, are the excessively loud fire alarms, some of which are jointly used as burglar alarms. Regional Public Health (2000a) has raised concern as did many respondents in this study. Some of the sirens were reported as so loud that children have been observed to be visibly distressed in fire drills by covering their ears with their hands, 'wetting their pants', and being in a state of panic. Respondents raised concern that apart from the unacceptable distress that some alarms cause, having children in such a distressed state could severely compromise a safe, speedy, and orderly evacuation.

Clause 406.3 of the New Zealand Standard (NZS 4512:2003) for fire detection and alarm systems in buildings requires:

- *The sound pressure level shall exceed by a minimum of 5 dB A, the noisiest background sound pressure level averaged over a 60s period.*

- *The sound pressure level of audible signals shall not be less than 65 dB A and not more than that 100 dB A measured at any normal accessible point in the room at a height of 1.8m.*

However, Clause 406.5 states:

Where audible-alerting devices could cause occupants distress in areas of buildings, or where such devices would preclude proper conduct or critical emergency function, other suitable means of quickly alerting occupants shall be permissible in those areas as follows.

a) In care or detention facilities in which there are on-duty staff available on a 24-hour basis, low level audible and/or visual devices shall be provided so as to alert all such staff whenever they may be located and whatever normal duties they may be undertaking.

In the case of early childhood centres, Clause 405 is applicable as loud audible alarms have been shown to cause distress to young children and could compromise a safe and effective evacuation. On duty staff are required to be available for the full duration that early childhood centres are in operation and children are present. There is no need for on duty staff to be available 24 hours a day for day facilities that cease to operate at night and on weekends. This clause would apply to hospitals and should apply to early childhood facilities. The present situation with excessively loud fire alarms in early childhood centres is unsatisfactory and needs urgent attention. Alarms, in many cases, will be needed after hours when the centres are unoccupied. As they will be alerting those in the vicinity rather than occupants, they would need to be of suitable sound and volume. However, this should not dictate the type of alarm system, or the type of sound or volume to which the occupants are exposed when the centre is in operation.

The Proposed Legislative Framework

The New Zealand Ministry of Education began a major revision of the early childhood legislation under its direction in 2003. Initial consultation with stakeholders revealed noise to be a major issue, which needed addressing (personal communication, Pairman 2003) and so noise provisions in the new legislation have been of major importance.

Current legislation

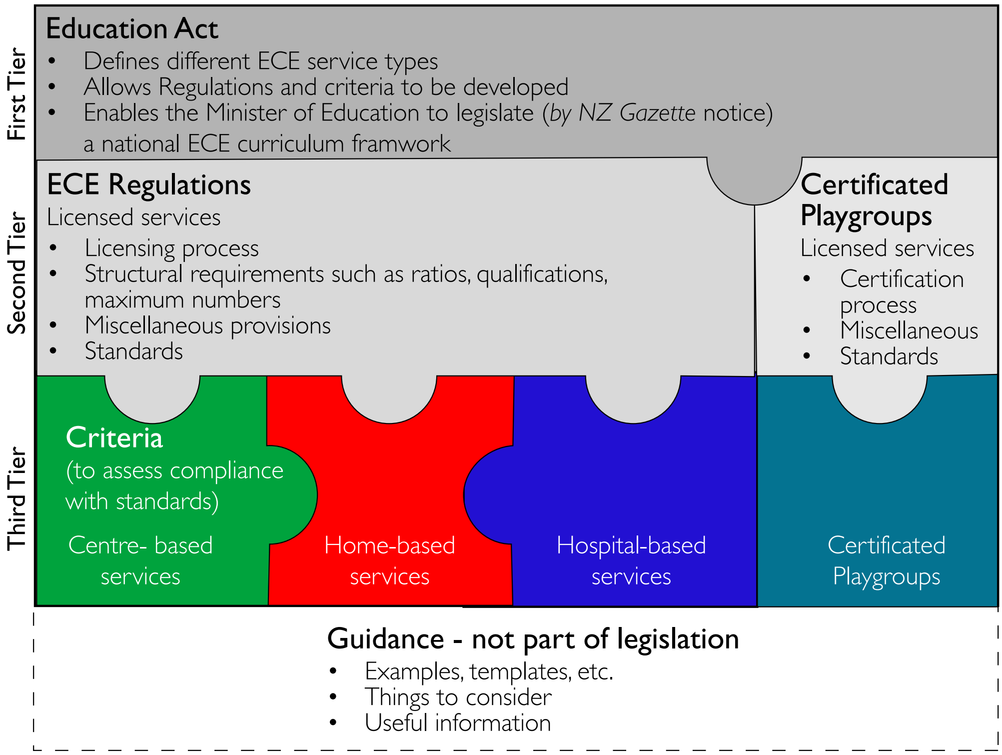
The current legislation for the control of early childhood legislation comprises two levels or tiers. The primary or first level is the *Education Act 1989* and at the second level are the Education (Early Childhood Centres) Regulations 1998 that are made pursuant to the Act.

Proposed revision

The Ministry of Education proposes a three level framework, which in effect adds a third level, or tier to the legislation, which will fit under the regulations as follows (Figure 1).

The Education Act 1989 has been amended by addition of a new section to cover all Early Childhood Education services. The Act will define the various

Figure 1: Proposed Legal Framework for Licensed Early Childhood Centres (New Zealand)



Source: Ministry of Education, New Zealand 2006, p.6

services types; permit the development and promulgation of Regulations and Criteria. A new set of regulations will detail the licensing process, indicated structural requirements (for example, ratios, qualifications, board standards and miscellaneous provisions such as the role of the Ministry in the sector (Ministry of Education 2006).

The Ministry of Education (2006) released the *Draft criteria for licensing or certification of ECE (early childhood education) services: Discussion document* after the passing of the second reading in Parliament. The Ministry has embraced recommendations made by McLaren and Dickinson (2005a) and adopted the *All Practicable Steps* model in noise management. In deciding to accept this model the Criterion Team of the Ministry of Health stated that they considered this approach could be implemented with current resources and was flexible enough to incorporate the wide raging characteristics of early childhood education in this country. Further, they did not wish to introduce a regime requiring high levels of expertise of equipment not widely available (personal communication, Hansen-White).

Three principal clauses in the *Draft Licensing Criteria for Centre-Based ECE Services* related to noise are as follows:

Clause 2.16: HEATING LIGHTING AND VENTILATION

- Parts of the building used by children have acoustic absorption materials necessary to reduce noise levels that may negatively affect children's wellbeing.

Clause 2.27: SLEEP FACILITIES FOR ALL DAY CENTRES

- If children under the age of two attend, there is a room available (separate to any activity space) to support the provision of restful sleep at any time they are attending. This room can be closed off from activity areas so that fluctuations in temperature, noise and lighting levels can be kept to a minimum.

Clause 3.20: NOISE

- All practicable steps are taken to ensure that noise levels do not unduly interfere with speech and /or communication or cause any children attending distress or harm.

Rationale

A number of studies, including those by Picard and Bradley (2001) and Nelson and Solti (2000), have found noise to be a critical element in effective speech and communication. Excessive noise or noise which masks critical elements of speech perception can have a serious effect on the process of children being able to understand their teacher and other children. Effective speech intelligibility requires a signal-to -noise ratio of 15dB. This means that the teacher's voice (the signal) needs to be 15 decibels above the background noise level. It is a good practical measure to judge noise levels against normal speech and communication. If the teacher has to shout to be heard, then the levels of noise are too high. In the presence of special needs children such as the hearing impaired and those with auditory processing difficulties, a higher signal-to-noise ratio might be required. The interactive learning space of an early childhood education centre is obviously going to generate noise from free play and learning by interaction of children with each other and with their teachers. The challenge for all teachers is to achieve a balance between what is excessive noise, and that which is a consequence of children's learning, and the participation in and enjoyment of the activities. To achieve effective speech communication a teacher speaking at 65 dB would need a background noise level of 50-55 dB. This outcome appears a practical way to control noise levels.

There is some debate over the safe levels of noise for children. The World Health Organization (1999) while recognising that more work needs to be done in this area, believes that A frequency weighted time average levels averaged over 8 hours of 75 dB or less ($L_{Aeq\,8h}$ <75 dB) are unlikely to cause hearing loss in the majority of the worldwide population. The risk of health issues concerning teachers such as hearing loss from excessive exposure and vocal strain is likely to be reduced from effective control of noise.

Protection of Special Needs Children

Clause 3.20 refers to noise, which could cause children distress or harm. This clause, while very wide reaching, primarily addresses the issues for special needs children who are adversely affected by noise. The draft criteria aim to protect noise causing distress to a child with auditory problems such as Sensory Integration Dysfunction, a high-risk group (for example, autism, Asperger's syndrome and giftedness). This means that practical steps must be taken to protect an autistic child who is overwhelmed and distressed by the level of noise. This will be difficult if the noise is from an external source where the centre has no direct control over the sound. However, the taking of *All Practicable Steps* would mean to make reasonable attempts to have the noise nuisance abated by seeking the assistance of the Noise Control Officer of the territorial authority or even by direct negotiation with the person(s) or organisation making the noise. All Practicable Steps would also include making representations in the Consents process under the New Zealand environmental legislation controlling noise (*Resource Management Act 1991*) where affected parties are entitled to raise objection to any notifiable consent process, which is going to affect them.

Sleep provisions

The issue of effective measures to allow restful and adequate sleep was identified by Ministry officials in documents and consultation meetings held around the country. Some centres do not have adequate sleeping facilities and when space has become a premium it has been the sleep areas that have generally suffered by being reduced to make way for other activities. Clause 2.27 in effect requires a fully partitioned area (with its own air space) to mitigate the effects of noise disturbing sleeping infants and other affects such as fluctuations in temperature and lighting are to be kept to a minimum.

Acoustics

Clause 2.16 is relevant where poor acoustic conditions exist such as excessive reverberation times. The current AS/NZS 2107 standard requires a Reverberation Time of 0.4-0.6 seconds. In the case of hard reverberant surfaces giving rise to reverberation times, which would generally be greater than 0.8 seconds there would be a noticeable effect on speech intelligibility from excessive reverberation. Clause 2.16 could be used to require the fitting of acoustic absorption or insulation materials to reduce reverberation times to the current recommended level. If a proposed amendment to the New Zealand Building Codes is adopted, all new centres will have to meet the new criteria as part of the building consents process. However the code, while in itself not mandatory for existing centres, would provide a valuable guide in centres to meet the requirements of Clause 2.16 where an unsatisfactory acoustical environment exists.

Guidance Section

An innovative addition to the proposed legislative framework is the 'Guidance section'. While it is not part of the legislation, it could provide valuable assistance and tools to meet the requirements of each level of the legislation. Strategies to manage noise could be included in this section, such as an innovative traffic light system for noise developed by a local kindergarten. Some centres might like to develop a Noise Management Plan as part of their policy and procedures, and a template could be included in this section. A Noise Management Plan would consist of the centre identifying noise issues and the children at risk, and formulating strategies to control or mitigate the effects along with the management of children adversely affected.

The draft criteria do not specifically cover excessively noisy fire alarms. This has been identified as a serious issue with the potential to cause harm, distress and compromise an orderly, speedy and safe evacuation.

Conclusion

While no one piece of legislation can in itself fully control noise issues in childcare centres, the proposed criteria present outcome-based solutions to control noise. This has a number of advantages over the prescription of sound levels in terms of being able to be implemented. It encourages staff to take ownership of the issue by incorporating strategies to control noise as part of their teaching practice without fear that they might be exceeding a prescribed limit. It will be necessary also to address external noise issues from large construction works, and the territorial authorities that grant consents need to be aware of the issues such noise has on children in childcare centres in the vicinity.

A mandatory provision for separate fully partitioned quiet spaces is an area, which deserves further consideration, as this is a serious deficiency in many early childhood education centres. In addition, the issue of excessively noisy fire alarms needs addressing.

Acknowledgments

I would like to thank Philip Dickinson, Professor of Acoustics, Massey University, Wellington, and Kelly Hanson-White, Project Adviser, Criterion Development Team of the New Zealand Ministry of Education, for their input into this paper.

References

Australian and New Zealand Standard 2000, AS/NZS 2107:2000, 'Acoustics: Recommended sound levels for building interiors', Standards Australia, Canberra.

Bennetts, L.& Flynn, M. 2002, 'Improving the classroom listening skills of children with Down Syndrome by using sound-field amplification', *Down Syndrome Research and Practice*, vol. 8, no. 1, pp.19-24.

Flexer, C. 1997, 'Individual and sound-field FM systems: Rationale, description and use', *Volta Review*, vol. 99, no.3, pp.133-62.

Grebennikov, L. 2006, 'Preschool teachers' exposure to noise', *International Journal of Early Years Education*, vol.14, no.1, pp. 35-44.

Hanson-White, K. 2006, Personal communication, Criterion Development Team, New Zealand Ministry of Education.

Karabiber, Z., Lubman, D. & Sutherland, L. 2002, 'The I-INCE Technical Initiative: Noise and reverberation control in schoolrooms', Paper presented at Internoise 2002, The International Congress and Exposition of Noise Control Engineering, Dearborn, MI, USA, 19-21 August.

McLaren, S. 2005, 'Noise and at-risk children in early childhood education centres,' *Early Childhood Folio*, vol. 9, pp. 39-43.

McLaren, S. 2007, Unpublished data for PhD thesis (under preparation), Institute of Food, Nutrition and Human Health, Massey University, Wellington.

McLaren, S. & Dickinson, P. 2005a, 'Regulatory framework for the control and monitoring of noise in childcare centres: Discussion document', A report prepared for the Ministry of Education, New Zealand.

McLaren, S. & Dickinson, P. 2005b, 'Noise in early childhood centres and how safe is the level of noise', *New Zealand Research in Early Childhood Education*, vol. 8, pp. 71-9.

Ministry of Education 2006, 'Draft criteria for the licensing or certification of ECE services', Discussion document, Ministry of Education New Zealand.

New Zealand Standard, NZS 4512:2003, 'Fire detection and alarm systems in buildings, 2003', *Standards New Zealand*, Wellington.

Nelson, P.B. & Soli, S. 2000, 'Acoustical barriers to learning: Children at risk in every classroom', *Language, Speech and Hearing Services in Schools*, vol. 31, pp. 356-61.

Pairman, A. 2003, Personal communication, Ministry of Education.

Palmer, A.1998, 'Quantification of the ecobehavioural impact of a soundfield loudspeaker system in elementary classrooms', *Journal of Speech Language Hearing Research*, vol. 41, no.4, pp. 819-34.

Picard, M. & Bradley, J. 2001, 'Revisiting speech interference in classrooms', *Audiology*, vol. v40, pp. 221-44.

Regional Public Health, Wellington, New Zealand 2001a, 'Fire and Security Alarms', Strand 1 Well Being - Manu Atua, *Regional Public Health Newsletter*, vol. 6, no. 3, p. 3.

Regional Public Health, Wellington, New Zealand 2001b, 'Quiet Spaces !! shhh' Strand 1 Well Being - Manu Atua, *Regional Public Health Newsletter,* vol. 5, no. 1, p. 3.

Shields, J. 1998, *NAS Early Bird Programme: Parent Manual*, National Autistic Society United Kingdom, London.

World Health Organization (WHO) 1999, *WHO Guidelines for Community Noise*, <http://who.int/docstore/peh/noise/guidelines2.html>

Correspondence to:
Stuart J. McLaren
Institute of Food Nutrition and Human Health
Massey University
Private Box 756
Wellington
NEW ZEALAND
Email: S.J.McLaren@massey.ac.nz

Back to TOC

Cost-Effective Activated Sludge Process Using Effective Microorganisms (EM)

Venkatachalapathy Sekaran[1], Krishnan Rajagopal[1] and Shunmugiah T. Karutha Pandian[2]

[1]Alagappa Chettiar College of Engineering and Technology, Tamilnadu, India & [2]Alagappa University, Tamilnadu, India

The contaminants in wastewater are removed by physical, chemical, and biological means. The first two processes are known as primary treatment processes. In the conventional secondary treatment, biological treatment by activated sludge process is used for removal of biodegradable contaminants (colloidal or dissolved) in wastewater. Basically, these substances are converted into gases that can escape to the atmosphere and the biological cell tissue that can be removed by settling. The most common problems encountered in the operation of activated sludge plant are bulking of sludge, rising of sludge, and Nocardia foam. The cost-effective activated sludge process (CASP) is a modification of the activated sludge process (ASP), which reduces construction and operational costs. In this system, Effective Microorganisms (EM) play a vital role in digesting the organic matter present in the wastewater. To identify this effect, in this study a sample of municipal sewage is taken and treated in a conventional ASP as well as in CASP. In order to stimulate the CASP one reactor, Reactor Number 1, is operated with activated EM solution (diluted at the ratio 1:50 after activation at the ratio of 1:50) added once in two weeks and aerated continuously. A second reactor is operated as a conventional ASP. The quantity of air supplied, time of aeration and organic loading are kept the same for the conventional ASP and the CASP. The sludge obtained from the ASP and CASP reactors is subjected to zone settling and the behavior of both sludge types is studied. From the experimental data the thickener areas were determined for different sludge concentration using solids flux method. From the experiment, the result derived is that the CASP sludge is showing good settling character, two times that of the conventional activated sludge. From biokinetic study it was proved that the EM organism can take higher F/M ratio (1.36 -2.45) and have a higher decay coefficient (-0.165), when compared with ordinary (without EM) ASP organisms (0.195-0.538), (-0.04) respectively. Hence the sludge reduction was possible through quicker digestion, earlier completion of treatment that leads to reduction in aeration time, and eliminating thickener (secondary settling tanks) thereby reducing the construction and operation cost considerably.

Key words: *Activated Sludge Process; Effective Microorganisms*

Wastewater treatment objectives are accomplished by concentrating impurities into solid form and separating these solids from the bulk liquid. This concentration of solids referred to as sludge contains many objectionable materials such as soluble biodegradable organics, suspended organic materials, non-biodegradable organics and must be disposed of properly. Sludge disposal facilities usually represent 40% to 60% of construction costs of wastewater treatment plants and account for as much as 50% of the operating costs; sludge disposal is a major cause for a disproportionate sharing of operating difficulties. In design and operation, gravity thickeners are similar to the secondary clarifiers used in suspended growth systems. The thickening function is a major design parameter, and tanks are generally deeper than the secondary clarifiers to provide greater thickening property. A well-operated gravity thickener should be able to, at least, double the solids content of the sludge, thereby eliminating half the volume (Reynolds & Richards 1996, p. 604).

The Activated Sludge Process has been widely used as a method for treating domestic and industrial effluents. In the Activated Sludge Process (ASP), the role of recirculation pumps is to recycle the biological flocs from the secondary clarifier into the aeration tank to maintain the required concentration of biomass for metabolic reactions. The efficient functioning of the Activated Sludge Process depends on the proper control over the process parameters. One such parameter is the mixed liquor suspended solids (MLSS) in the reactor, to be maintained in a particular range. For this the sludge must settle properly and get consolidated into a concentrated suspension in the clarifier. These are the main aspects of the ASP. The cost of disposal of excess sludge has become increasingly higher accounting for about half, and even up to 60% of the total operational cost in wastewater treatment plants (Low & Chase 1999; Wei et al. 2003). It was also reported that the excessive activated sludge in biological process can possibly be reduced by: uncoupling metabolism (Mayhew & Stephensen 1997; Mark, van Loosdrcht & Henze 1999; Low et al. 2000), cryptic growth enhanced through cell lysis (Chen et al. 2001; Haner, Mason & Hamer 1994; Kamiya & Hirotsuji 1998), and micro fauna predation (Ghyoot & Verstraete 1998; Rocher et al. 1999).

Cryptic organisms named Effective Microorganisms (EM) were originally developed by Higa (1995). EM is a mixture of organisms that has a reviving action on humans, animals and the natural environment (Higa 1995). Studies have suggested that EM might have a number of beneficial applications, including in agriculture, livestock husbandry, gardening and landscaping, composting, bio-remediation, cleaning septic tanks, algal control and household uses (Higa & Chinen 1998). Recently, this has been simplified to representatives of three genera only, that is, bacteria, yeast, and photosynthetic bacteria.

The importance of kinetic parameters was highlighted in order to describe the metabolic performance of the microbial organisms when fed with the substrate and other components in the tannery effluent in an activated sludge system (Gurusamy & Elagovan 1992). In this study, in order to compare the metabolic performance of the effective microorganisms over the conventional microorganisms normally present in sewage substrate, the evaluation of kinetic parameters becomes a prime objective.

Materials and Methods

Batch study

The wastewater used for this study was domestic wastewater collected from a municipal drain (Grab samples of volume 100 litres, collected at 6 a.m., on alternate days during the months of June & July). Two containers of 10 litres each were used as a bench scale model reactor for this comparative study. Each reactor was provided with an air diffuser at the bottom and connected to an air pump to enable the supply of air to the basin. The reactors were operated simultaneously for attaining conditions of a steady state. Replacing 2 litres from the reactor, 2 litres of domestic wastewater were added to reactor number 1 (along with 20ml/L of activated effective microorganisms once in 15 days) and number 2 so that the mean cell residence time (θ_c) was maintained as 5 days.

Effective Microorganism is available in a dormant state as Effective Microorganism stock solution. Effective Microorganism requires activation before application. Activation (1:50 ratio) was carried out by mixing 1litre of Effective Microorganism, 1 kg of 'jaggery' (brown sugar) with 50 litres of water. These ingredients were mixed in a clean airtight plastic container so that no air was left in the container and stored away from direct sunlight in ambient temperature for 7 days, and the gas produced due to fermentation was released every day. A white layer of actinomycetes on top of the solution was formed accompanied by a pleasant odour. In addition, the pH of the product dropped below 4.0, which indicates the completion of activation.

The total microbial count of Effective Microorganism stock was determined by spread plate technique. The EM solution was serially diluted and plated on Nutrient agar (HiMedia) to enumerate the Total Bacterial Count and on Sabouraud's Dextrose Agar (SDA) (HiMedia) to enumerate yeast and molds. The colonies were isolated and maintained in pure culture. The bacterial genera were identified by performing various biochemical tests (Gram-Staining, Motility test, Catalase test, Oxidase test, Indole test, Methyl red test, Voges proskauer test, Citrate test, Nitrate reduction test, and Carbohydrate fermentation tests). The yeast and mold were identified by microscopic observation.

To characterise the bacterial load occurring before and during the activated sludge process, the bacterial growth curve was in three stages, namely, (i) Activated EM, (ii) Reactor Number 1 (EM, 'Jaggery' and Sewage mix) and (iii) Reactor number 2 (Only Sewage) were determined. The bacterial growth was estimated in the EM and Jaggery Mix to determine the number of bacteria present in the activated EM solution prior to the addition of the EM solution to the Reactor 1. After activation of the EM solution, samples were drawn at three different days (0th day, 1st day and 6th day). 1ml of sample from each day was serially diluted and spread plated on Nutrient agar. The plates were incubated at room temperature at 28-30°C. After incubation the colonies on the plates were enumerated. Bacterial load in Reactor 1 was done to estimate the trend of bacterial growth occurring each day (zeroth day-sixth day) after the addition of EM solution as mentioned above.

The bacterial load of Reactor 2 with only sewage was done to compare the bacterial growth with Reactor 1. The samples for bacterial analysis from Reactor 2 were drawn on the 0th day, 12th day, 15th day, 19th day and 28th day and processed as mentioned above. This will directly show the effect of using EM solution in activated sludge process.

The Reactor number 1 which had been seeded with EM solution at the ratio of 1:50 attained its steady state in 6 days whereas the reactor Number 2 (Only Sewage), which is operated as a conventional ASP, attained the steady state in 15 days. After attaining steady state, BOD of both influent and effluent were noted. MLSS values were taken continuously for the subsequent days in order to assess steady state conditions.

The initial sludge concentrations were estimated by gravimetric method. Sludge was collected from Reactor Number 1, which had an original concentration of 400 mg/L and reactor number 2 with a concentration of 2400 mg/L. The available sludge concentration in Reactor Number 1 was not sufficient for zone settling studies and for comparison of zone settling among the ASP sludge and CASP sludge. Three more additional reactors were taken and seeded with 1:50 activated EM, sludge was developed using the above method to reach a concentration of 3000 mg/L. The original concentration in the Reactor Number 2 was found to be 3500 mg/L. Different concentrations were prepared by diluting or concentrating the original concentration with the same supernatant liquor as shown in Table 1.

A laboratory bench scale model of a settling column with a diameter of 54mm and a height of 410mm was fabricated from glass to carry out the settling studies. After filling the column with each of the concentrations of suspended materials, slow stirring was done for 1-2 minutes to keep the initial concentration of the sample uniform throughout the depth of the column. Time periods for the known descent of the interface between the formed sludge blanket and the clarified supernatant

Table 1: Values of prepared concentrations (mg/L)

S.NO.	1	2	3	4	5	6	7	8	9
Concentrations (in mg/L) prepared for ASP & CASP	2400	2700	3000	3300	3600	3900	4200	4500	4800

were noted. Such tests were conducted for different concentrations for about 30 minutes and within this time the settling curve became almost parallel to the time axis.

Evaluation of Kinetic Parameters of CASP and ASP

Continuous test

Five identical laboratory scale completely mixed continuous flow activated sludge reactors with internal recycle were used for the evaluation of kinetic parameter. The reactors had an aeration basin of 3 litres capacity, an internal clarifier basin with an adjustable baffle, and with effluent gravity overflow arrangement. A schematic of one such experimental set up is shown in Figure 1. Compressed air was introduced into each system separately and the DO concentration in each reactor was never allowed to drop below 3mg/L. Sewage samples collected from the municipal drain were given primary settling for a period of 2hrs and the activated sludge was fed with the settled sewage with a hydraulic retention time of 8hrs. Once a day, the sludge was wasted from the reactor and the wasted

Figure 1: Experimental setup

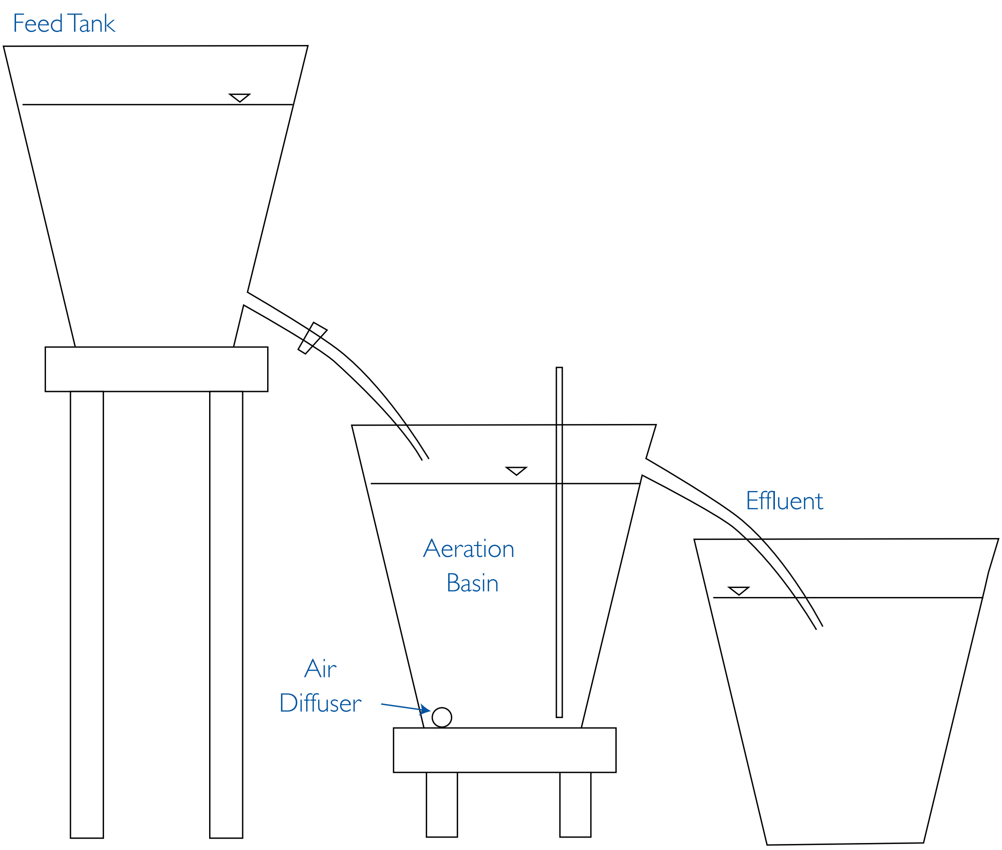


Table 2: Summary of steady-state run with settled sewage in ASP

So mg/L	S mg/L	θ_c days	θ_c days	MLVSS mg/L	F/M Ratio	BOD removal efficiency (%)	θX days mg/L	I/S x 10^{-2} $(mg/L)^{-1}$	θX/(So-S) (days)	(So-S)/θX $(days)^{-1}$	$1/\theta_c$ $(days)^{-1}$
183	26	0.333	13.33	2820	0.195	85.8	939.06	3.8	5.981	0.167	0.075
183	30	0.333	10.00	2400	0.228	83.6	799.2	3.3	5.224	0.191	0.100
183	34	0.333	8.0	1830	0.300	81.4	609.39	2.9	4.090	0.245	0.125
183	42	0.333	5.0	1620	0.387	77.0	539.46	2.4	3.825	0.261	0.200
183	46	0.333	4.0	1020	0.538	74.9	339.66	2.2	2.479	0.403	0.250

Table 3: Summary of steady-state run with settled sewage in CASP

So mg/L	S mg/L	θ days	θ_c days	MLVSS mg/L	F/M Ratio	BOD removal efficiency (%)	θX days mg/L	I/S x 10^{-2} $(mg/L)^{-1}$	θX (So-S) (days)	(So-S)/ θX $(days)^{-1}$	$1/\theta_c$ $(days)^{-1}$
185	21	0.333	13.33	407	1.364	88.6	135.531	4.76	0.826	1.21	0.075
185	24	0.333	10.00	353	1.572	87.0	117.549	4.17	0.730	1.370	0.100
185	29	0.333	8.00	320	1.734	84.3	106.56	3.44	0.683	1.464	0.125
185	36	0.333	5.00	247	2.247	80.5	82.251	2.78	0.552	1.811	0.200
185	41	0.333	4.00	227	2.445	77.8	75.591	2.44	0.525	1.905	0.250

volume was replaced with treated effluent. The activated sludge system was operated until a stabilised condition was achieved as represented by sludge growth on a day to day basis and effluent BOD remained constant and persisted for at least 3 days. The data under stabilised conditions were averaged and employed as a single point in the correlation. The mean cell residence time θ_c was varied from 4.0 to 13.333 day by operating the reactor at varying F/M.

The same procedure was adopted also in the case of CASP, for the determination of kinetic parameters of EM. Parameters measured during the study were the influent and effluent substrate concentration in terms of BOD (So and S), mixed liquor suspended solids (MLSS), mixed liquor volatile suspended solids (MLVSS). BOD of influent and effluent were measured using Lovibond analyser, and all the other analyses were conducted in accordance with the standard methods. The results are tabulated in Tables 2 and 3.

Results and Discussion

The Total Bacterial Count of The EM solution was 1.5 x 10^7 cfu/ml. Monotypic colony morphology was observed on the Nutrient Agar plates as shown in Figure 2(a). On performing biochemical tests the bacteria was identified as *Bacillus spp*.

Both Yeast and Mold growth were observed on the Sabouraud's Dextrose Agar (SDA) plates as shown in Figure 2(b). The total yeast count was 4.7 x 10^4 cfu/ml and mold count was 3.6 x 10^4 cfu/ml. The yeast and mold were identified by morphological and microscopic observation. The yeast was identified as *Saccharomyces spp* and mold as *Mucor spp*. as shown in Figure 2(c).

From the results of the EM and Jaggery Mix sample, the bacterial count was nil in the zeroth day. In day 1 about 3.5x10^3 cfu/ml and day 6 showed a high number of cells up to 3.0x10^5 cfu/ml. The obtained results are shown in Table 4 suggest that jaggery plays as a suitable medium for the growth of the bacteria present in the Effective

Figure 2(a): Bacteria growth

Figure 2(b): Mold growth

Figure 2(c): Yeast growth

Table 4: Bacterial count of EM and jaggery

Sl. No	Days	No. of Colonies (cfu/ml)
1.	0th Day	Nil
2.	1st Day	3.5×10^3
3.	6th Day	3.0×10^5

Microorganism stock solution by providing carbon source to the bacteria. The result also insists that activation of EM solution is necessary and a very important step to achieve a cost effective activated sludge process as the step of activation increases the bacterial cell number to several folds as shown in Figure 3.

The bacterial growth curve of Reactor 1 shows that at zeroth day, the bacterial cell number was 3.5 x 10^5 cfu/ml. A sudden increase in the cell number was noticed in 1st day 4.8 x10^7 cfu/ml and the same cell density (around 10^7 cfu/ml) were maintained up to the sixth day as shown in Figure 4(a). The results are shown in Figure 4(b) shows that there is a rapid increase in cell number from zeroth day to the 1st day. From the 1st day to the 6th day, a steady state is maintained.

Figure 3: EM Growth in jaggery

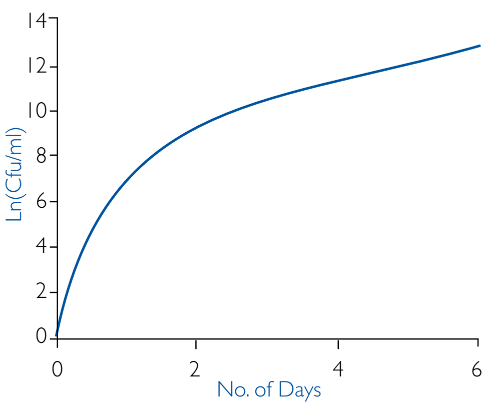


Table 5: Bacterial count of sewage samples

Sl. No	Days	No. of Bacteria (cfu/ml)
1.	0th Day	6.2×10^6
2.	12th Day	8.0×10^4
3.	15th Day	3.2×10^5
4.	19th Day	7.0×10^4
5.	28th Day	3.0×10^5

The photos presented in Figure 4(b) show that up to the third day mixed bacterial cultures can be observed. From the 4th day only monomorphic colonies were observed which resembles the colonies of Figure 2(a). This shows that bacteria present in the EM solution predominantly grow from the 4th day in Reactor 1.

The bacterial growth curve of Reactor 2 in Figure 5(a) shows that at zeroth day the bacterial cell number was 6.2 x 10^6 cfu/ml. There is a considerable decline in the number of cells in the sewage from 0th day to the 12th day as presented in Table 5. From 12th day, a steady state is maintained up to the 28th day and the results are presented in graph as well as photos are presented in Figure 5(b). This states that without EM solution, the conventional activated sludge process takes almost 12 days to reach a steady state, unlike Reactor Number 1, which takes only 6 days. This justifies that the bacteria in the EM solution plays a crucial role in enhancing the efficiency of the activated sludge process.

In both the reactors, the MLSS developed were noted at a regular interval of time to confirm steady state conditions. The MLSS values developed were tabulated in Table 6. From Table 6 it shows that the steady state

Figure 4 (a): Graph showing the bacterial count of EM and sewage mix

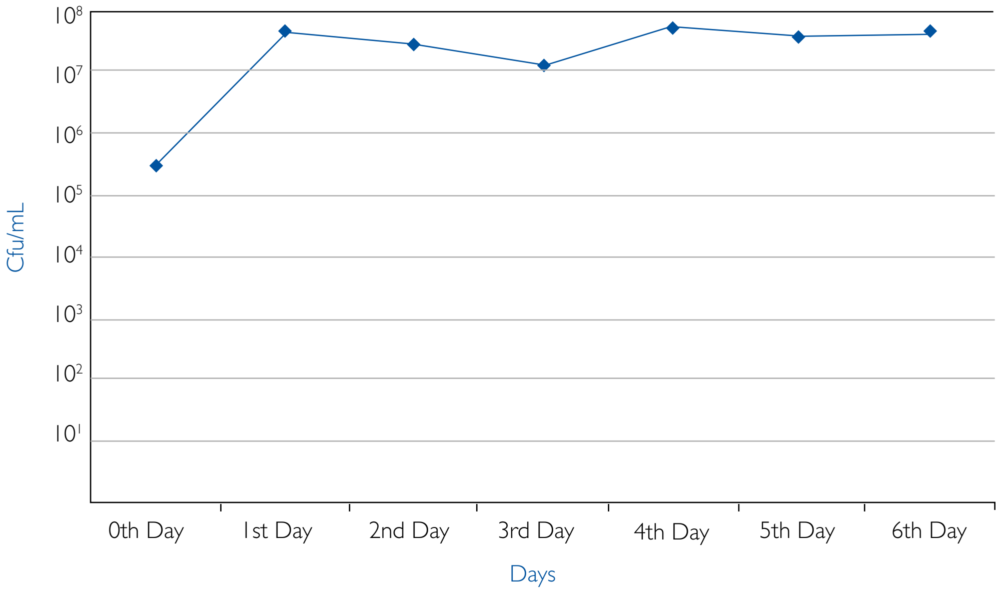


Figure 4(b): Plates showing bacterial colonies of 0th day to 6th day samples collected form Reactor 1 (activated EM and sewage mix)

0th Day Sewage

1st Day

2nd Day

3rd Day

4th Day

5th Day

6th Day

for Reactor Number 1 was reached in 6 days with a sludge concentration of 400 mg/l, which is considered to be a low value. Whereas in reactor 2 it took 15 days to reach steady state with a sludge concentration of 3500 mg/L.

From this it is clear that, for the CASP, the time required to attain a steady state is very short (i.e. 6 days) compared to the conventional ASP (i.e. 15 days). Table 7 shows BOD both CASP and ASP reactors. After attaining the steady

Table 6: Monitored values of MLSS (mg/L)

DAYS	CASP	ASP
1	250	350
2	250	410
3	300	460
4	350	700
5	400	790
6	400	950
7	400	1100
8	400	1190
11		1500
12		2100
13		2600
14		3100
15		3500
21		3500
23		3500
25		3500
27		3500
28		3500

state condition, the CASP reactor showed a BOD reduction of 85.6 % whereas the conventional ASP showed a reduction of only 64.9 %. For mean cell residence times of 1 day and 5 days the BOD removal for the CASP reactor was observed as 90.9 % and 94.2% respectively. Where as for the same θ_c, in the ASP the BOD removal were 72.7 % and 83.5% respectively. This indicates that the effective microorganisms are playing a vital role in the consumption of dissolved/colloidal organics present in the reactor.

The results of kinetic parameters evaluation study were tabulated in Table 2 and Table 3. The following modified Monod equations were used to develop kinetic parameters:

$$\frac{1}{U} = \frac{Ks}{k} \times \frac{1}{S} + \frac{1}{k} (1) \text{ and } \frac{1}{\theta_c} = Y\ U\ - K_d\ .(2); \text{ where } U = \frac{X\theta}{S_0 - S}$$

For all the graphs, the method of least squares was used to obtain the line of best fit. Average values for the reciprocal of the mean suspended solids retention time ($1/\theta_c$) were plotted against food to micro organism ratio (U). The reciprocal of food to micro organism ratios (1/U) were plotted against the reciprocal of effluent BOD (s). The substrate removal constants K_s, k, sludge production constant Y, and decay constant K_d were determined and tabulated in Table 8.

From the observed data of settling tests, the plots were encoded between interface height and time for different initial suspended solids concentrations for sludge samples from the CASP and ASP. From these plots, zone settling velocities have been determined for each of the suspended solids concentration and the same is given in Table 9 for both CASP and ASP reactors.

From Table 9 it can be observed that the zone settling velocity is decreasing with increase in suspended solids concentration. The decrease in zone settling velocity may be due to higher resistance offered for settling at increased concentrations. Zone settling

Table 7: Monitored BOD values

Duration of Aeration	CASP			ASP		
	Influent BOD mg/L	Effluent BOD mg/L	% Removal	Influent BOD mg/L	Effluent BOD mg/L	% Removal
After attuning steady state	230	33	85.6	225	79	64.9
Mean cell residence of 1 day	220	20	90.9	220	60	72.7
Mean cell residence of 5 days	223	13	94.2	231	38	83.5

Table 8: Summary of kinetic constants obtained

Particulars	Experimental Values obtained	
	CASP	ASP
Substrate removal constants		
Ks mg/L	57.91	188.5
K, day $^{-1}$	4.55	1.43
Sludge production constant Y	0.72	0.202
Decay constant k_d, day $^{-1}$	- 0.165	- 0.04

Table 9: Zone settling velocity for different suspended solids concentration

Sl. No.	Concentration mg/l	Settling Velocity for CASP sludge (m/hr)	Settling Velocity for ASP Vs (m/hr)
1	2400	20.50	16.40
2	2700	14.47	12.30
3	3000	11.71	6.83
4	3300	10.25	5.12
5	3600	8.20	4.64
6	3900	7.33	3.32
7	4200	6.83	2.89
8	4500	5.47	2.14
9	4800	3.73	1.77

Table 10: Limiting solids flux for different underflow concentration for CASP

C_u (kg/m^3)	6.6	7.4	8.2	9.2	10.1
G_L (kg/m^2.hr)	63.0	46.5	36.0	21.0	13.0

Table 11: Limiting solids flux for different underflow concentration for ASP

C_u (kg/m^3)	6.1	6.6	7.1	7.8	8.5
G_L (kg/m^2.hr)	33.0	25.0	19.5	10.5	7.5

Table 12: Solids Flux loading for different underflow concentration.

C_u (kg/m^3)	G_L (kg/m^2.hr)	
	CASP	ASP
6.0	68.56	32.25
6.5	61.45	26.86
7.0	54.35	21.47
7.5	47.25	16.08
8.0	40.14	10.69
8.5	33.04	5.30

velocity for the concentrations of 2400 mg/L and 4800 mg/L is 20.50 m/hr and 3.73 m/hr in CASP whereas in ASP it is 16.40m/hr and 1.77 m/hr, which shows that in CASP the velocity increases by 1.15 times to 2.21 times in comparison to ASP. From the settling curves it can bee seen that in the CASP, the settling time for all concentrations is within 6 minutes, whereas in ASP it goes up to 30 minutes. The quick settling of the biofloc in CASP infers that there is no need for a separate settling tank. An attempt has been made to develop the model for thickener areas for different desired underflow concentrations with the available settling data for both CASP and ASP.

The data-relating zone settling velocity (Vs) and initial suspended solids concentration (C_0) appear to yield a relationship of the type shown in equation 3, as suggested by Baskin and Suidan 1985.

$$\log V_s = a + b\, C_0 \qquad (3)$$

Through the regression of the data shown in Table 9, the constants for the above equation were evaluated, and the equations for CASP and ASP are given below in (equation 4 and 5).

$$\log V_s = 2.03 - 0.00031\, C_0 \qquad (4)$$
$$\log V_s = 2.092 - 0.0004\, C_0 \qquad (5)$$

In the above equations, Vs represents the zone settling velocity in m/hr, C_0 represents initial suspended solids concentration in mg/l. The correlation coefficients for equations 4 and 5 work out to be 0.99. Using the equations 4 and 5, solid flux values were calculated for different initial concentrations of sludge. The solid flux curves were drawn for CASP and ASP reactors and are presented in Figure 6 and Figure 7.

These solids flux curves were utilised for determining the limiting solids flux for different underflow sludge concentrations. The underflow sludge concentrations are chosen and the limiting solids flux are determined for each type of the thickener and presented in Table 10 and Table 11.

Figure 5(a): Graph showing the bacterial growth in sewage

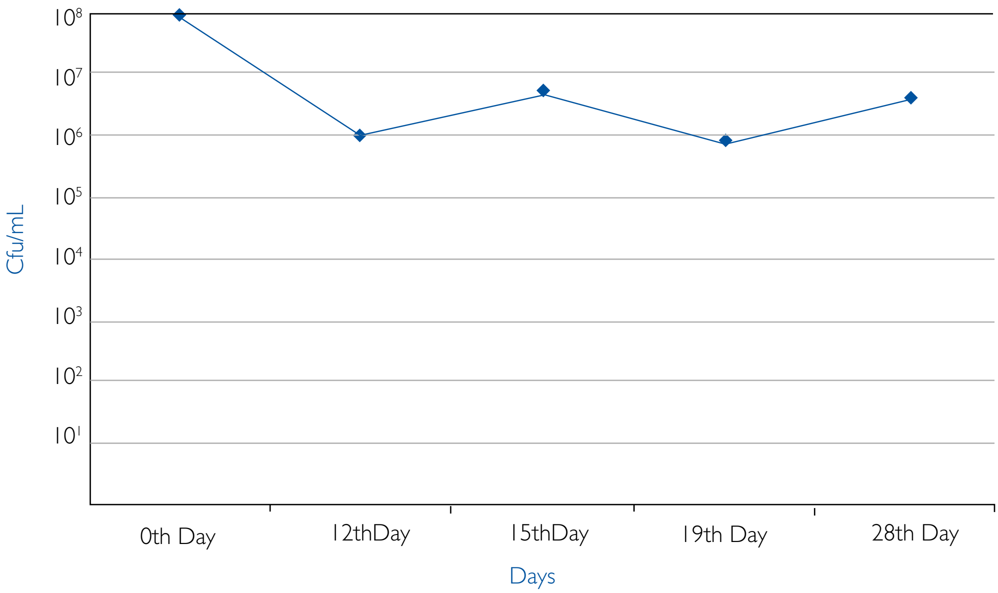


Figure 5(b): Plates showing bacterial colonies of 0th day, 12th day, 15th day and 19th day. Effluent samples collected form Reactor 2 (sewage only)

0th Day | 12th Day | 15th Day | 19th Day

To obtain the relationship between limiting solids flux (G_L) and desired underflow sludge concentration (C_u), several equations were tried and success was met with the following equations.

For CASP $G_L = 153.82 - 14.21\ C_u$ (6)

For ASP $G_L = 96.93 - 10.78\ C_u$ (7)

The constants for the above equations were obtained through the regression of the data presented in Table 10 and Table 11. In equations 6 and 7, G_L represents the limiting solids flux in kg/m^2.hr and Cu represents underflow sludge concentration in kg/m^3. The correlation coefficient 0.99 and 0.98 were obtained for the above equations.

By using the equation, the desired underflow sludge concentrations were chosen as 6.0 to 8.5 kg/m^3 at an interval of 0.5 kg/m^3 for both reactors and the limiting solids flux were obtained and they are presented in Table 12.

By material balance, the area of the thickeners for unit discharge (1 m^3/hr) can be calculated using the Equation 8.

$$A = \frac{C_0}{G_L} \qquad (8)$$

Where, C_0 = Initial solids concentration

G_L = Limiting solids flux

For a C_0 value of 2.4 kg/m^3, using the G_L values are presented in Table 10 for different C_u values, the areas were calculated for both reactors and the same are given in the Table 13.

From Table 13 it is seen that for, underflow concentration of 6.0 kg/m^3, 8.5 kg/m^3 without

Figure 6: Solids flux curve for CASP sludge

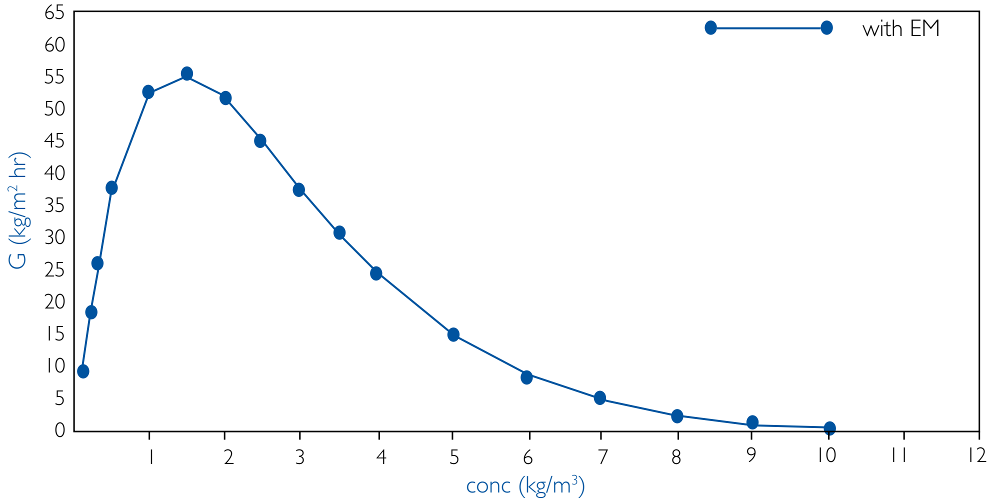
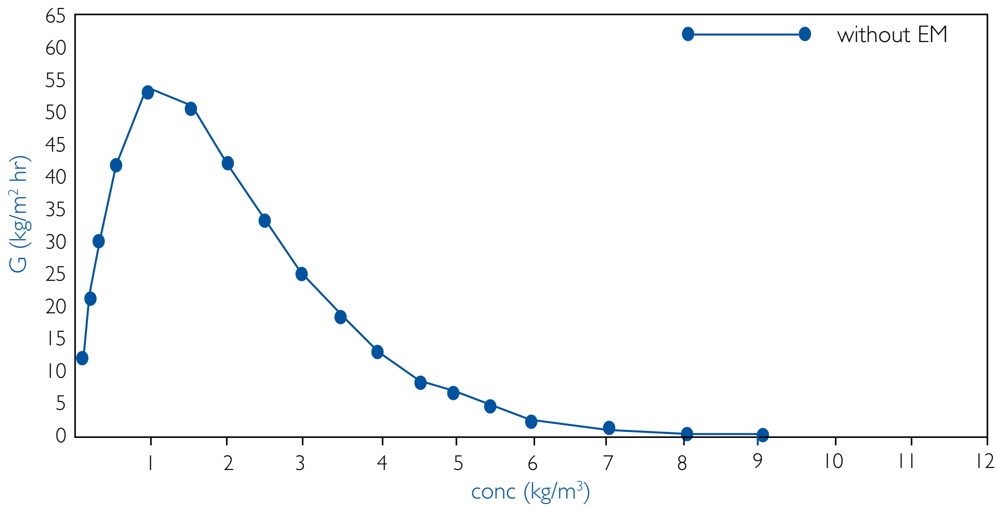


Figure 7: Solids flux curve for ASP sludge



recycle the % reduction in thickener area were 52.98 and 83.89 respectively. This shows that the area required can be minimised and there is no necessity to have a separate secondary settling tank and the same can be merged with the aeration unit itself.

Table 13: Calculated values of thickener area for CASP and ASP for various values of underflow sludge concentration C_u.

C_u kg/m³	CASP Area, m²	ASP Area m²	% Reduction in area
6.0	0.035	0.074	52.98
6.5	0.039	0.089	56.18
7.0	0.045	0.112	59.82
7.5	0.051	0.149	65.78
8.0	0.066	0.225	70.69
8.5	0.073	0.453	83.89

However, by means of recirculation of the activated sludge for an assumed condition of the MLSS of 4375 mg/L the recirculation ratios have been obtained for both the reactors and the secondary settling tank areas were determined for various underflow concentrations, and they were shown in Table 14.

From Table 14 it is observed that for an underflow concentration of 6.0 kg/m³ and 8.5 kg/m³ with recirculation rate of 2.69 and 1.06

Table 14: Calculated values of thickener area for CASP and ASP for various values of recirculation ratio _ and underflow sludge concentration

C_u Kg/m³	Recirculation ratio θ	Area m²		% Reduction
		CASP	ASP	
6.0	2.69	0.2355	0.501	52.99
6.5	2.06	0.2179	0.4984	56.28
7.0	1.67	0.215	0.544	60.48
7.5	1.40	0.222	0.653	65.97
8.0	1.21	0.241	0.905	73.37
8.5	1.06	0.2728	1.699	83.95

respectively, the reduction in thickener area was found as 52.99 and 83.95 respectively. From this it can be concluded that the separate thickening unit (secondary settling unit) can be eliminated from the CASP.

With reference to Table 8, it was found that the sludge production constant 'Y' for CASP [0.202] is much lower than that for the ASP [0.72]. Moreover the decay constant [-0.165] is much higher than that for the ASP [-0.04]. The above factor clearly shows that the Effective Microorganisms are more effective in degrading the biological organic matters in a lesser time and with less amount of sludge. This reduces the cost of separate recirculation unit. Sludge recirculation can be accommodated inside the aeration unit, which makes the CASP a unique process with improved cost-efficiency and energy savings.

Conclusion

The following conclusions can be drawn from the present study. The steady state in the CASP is reached in shorter time than in the ASP, thus aeration time is reduced. The zone settling velocity increases by two times in the CASP in comparison to the ASP.BOD removal in the CASP will be high, and that too is achieved in a short time. Solids flux loading is more in the CASP. In CASP, the application of EM leads to reduction of volume of sludge, BOD and solids contents. Reduction of sludge solids leads to a diminished need for handling of solids (i.e. reduced requirement for desludging) thereby reducing expenses in maintenance and operation. Reduction in settling time and in sludge volume produced in CASP leads to diminished thickening area, and thereby eliminates the thickening unit from CASP.The EM organism can take higher F/M ratio (1.36-2.45) and have a higher decay coefficient (-0.165), when compared with ordinary (without EM) ASP organisms (0.195-0.538), (-0.04) respectively.

Acknowledgments

The authors acknowledge the help rendered by Mr P. Nithyanand, Research Scholar, Department of Bio-Technology, Alagappa University, Karaikudi-630003, in the microbial analysis of EM1.

References

American Public Health Association (APHA), American Water Works Association (AWWA), Water Environment Federation (WPF) 1998, *Standard Methods for the Examination of Water and Wastewater*, 20th edn, American Public Health Association, Washington DC.

Baskin D.E. & Suidan M.T. 1985, 'Unified analysis of thickening', *Journal of Environmental Engineering Division*, American Society of Civil Engineers, vol. III, pp. 10-20.

Chen, G.H, Saby, S. Djafer, Mo, H.K. 2001, 'New approaches to minimize excess sludge in activated sludge systems', *Water Science & Technology*, vol. 44, pp. 203-8.

Fretig, D.G. 2000, 'The use of effective microorganisms in organic waste management', Effective *Microorganisms@emtrading.com*, updated 3 May 2000, accessed 27 August 2002.

Ghyoot, W. & Verstraete, W. 1998, 'Reduced sludge production in a two-stage membrane: Assisted bioreactor', *Water Research*, vol. 34, pp. 205-15.

Gurusamy, R. & Elangovan, R. 1992, 'Evaluation of kinetic parameters of activated sludge treating chrome tannery waste', Indian *Journal of Environmental Protection*, vol.12, no.2, pp. 110-4.

Haner, A., Mason, C.A. & Hamer, G. 1994, 'Death and lysis during aerobic thermophilic sludge treatment: Characterization of recalcitrant products', *Water Research*, vol. 28, pp. 863-9.

Higa, T. 1995, *What is EM Technology?* College of Agriculture, University of Ryukyus, Okinawa, Japan.

Higa, T. & Chinen, N. 1998, *EM Treatment of Odor, Wastewater, and Environmental Problems*, College of Agriculture, University of Ryukyus, Okinawa, Japan.

Kamiya, T. & Hirotsuji, J. 1998, 'New combined system of biological process and intermittent ozonation for advanced wastewater treatment', *Water Science Technology*, vol. 38, pp. 145-53.

Low, E.U. & Chase, H.A. 1999, 'Reducing production of excess biomass during wastewater treatment', *Water Research*, vol. 33, pp. 1119-32.

Low, E.U., Chase, H.A., Milner, M.G. & Curtis T.P. 2000, 'Uncoupling of metabolism to reduce biomass production in activated sludge process', *Water Research*, vol. 34, pp. 3204-12.

Mayhew, M. & Stephenson, T. 1997, 'Low biomass yield activated sludge: A review', *Environment Technology*, vol. 18, pp. 883-92.

Mark, C., van Loosdrcht, M. & Henze, M. 1999, 'Maintenance, endogenous respiration, lysis, decay and predation', *Water Science Technology*, vol. 39, pp. 107-17.

Reynolds, T. D. & Richards, P. A. *Unit Operations and Processes in Environmental Engineering*, 2nd edn, PWS Publications, Boton MA.

Rocher, M., Goma, G. Bengue, A.P., Louvel, L. & Rols, J.L.1999, 'Towards reduction in excess sludge production in activated sludge process: Biomass physicochemical treatment and biodegradation', *Applied Microbiology and Biotechnology*, vol. 51, pp. 883-90.

Saby, S., Djafer, M. Chen, G.H. 2002) Feasibility of using a chlorination step to reduce excess sludge in activated sludge process, *Water Research* 36, 656-666.

Wei, Y.S, Van, H.R.T. Borger, A.R. et al. 2003, 'Minimization of excess sludge production for biological wastewater treatment', *Water Research*, vol. 37, pp. 4453-67.

Correspondence to:
V. Sekaran
Alagappa Chettiar College of Engineering and Technology
Karaikudi 630004 Tamilnadu
INDIA
Email: vsek01@yahoo.com

Back to TOC

Environmental Health Policy

David Ball

Open University Press/McGraw Hill, 2006, 283 pp, ISBN-10: 0 335 21843 1, RRP $49.95 (paperback)

Environmental Health Policy is one of a series of 20 books in the *Understanding Public Health* series which is based on material taught at the London School of Hygiene and Tropical Medicine. Even though each text stands alone, together they provide a comprehensive overview of the foundational topics for the study and practice of public health. From an environmental health perspective, other titles in the series that are of interest include: *Controlling Communicable Disease*, *Environmental Epidemiology*, and *Environment, Health and Sustainable Development*.

Environmental Health Policy takes a multidisciplinary approach to providing an overview of what environmental health policy is, the tools that are used to develop this type of policy, and the considerations that are relevant for implementing policy. The text is comprised of seven sections and 20 chapters. The first section provides an introduction to environmental health and policy and provides a brief introduction to various tools that are used to develop environmental health policy. Section 2 provides an overview on human health risk assessment, which the text identifies as being the main tool used to inform the development of environmental health policy. The text also states that this is the primary tool that provides scientific input into the policy process. This section, therefore, describes the generic health risk assessment approach and then discusses each of the stages of health risk assessment (that is, hazard identification, dose-response assessment, exposure assessment, and risk characterisation). The next section discusses the role of economic evaluation in policy development and then presents a number of case studies on the national and international frameworks for managing specific environmental, radiological and safety hazards. These policy frameworks are presented as examples of the scientific (health risk assessment) and economic considerations previously discussed.

Section 4 then discusses approaches that move beyond the 'rational' approach taken by science and economics, and how these approaches can influence policy-making. This section discusses alternative theories of risk, risk perception and the psychometric paradigm, and cultural theory. Section 5 moves on to discussing alternative approaches to assessing health risk, such as environmental, social and health impact assessment, environmental risk ranking, and alternatives assessment. This section identifies the merits and limitations of each of these approaches. Section 6 then goes on to discuss specific influences and approaches to policy-making, such as risk communication and participatory decision making, philosophy, politics and prejudice. The final section discusses some current local and global environmental health policy initiatives. These include Agenda 21, Capacity 21 and a range of initiatives aimed at creating healthy communities. Stratospheric ozone depletion and greenhouse gas emissions are also discussed as policy issues requiring global initiatives. This section focuses on the effectiveness of these particular initiatives and on some of the barriers to creating international agreements.

The text is well set out to facilitate self-directed learning with each chapter having learning objectives, activities and feedback sections on the activities. There are also an appropriate number of figures that illustrate specific concepts. As the specific topics are covered in relatively small sections and written in an easy-to-read style, the layout helps greatly to improve understanding of the content.

Overall, this text nicely pulls together a range of topics and tools (that are often not viewed as being interrelated) and then describes their role in the context of environmental health policy development and implementation. As such, I would recommend this text to students as an introduction to environmental health policy and practice, and to practitioners as a refresher course on policy development tools and processes.

Thomas Tenkate
School of Public Health
Queensland University of Technology
Email: t.tenkate@qut.edu.au

Back to TOC

Essentials of Environmental Health

Robert H. Friis

Jones & Bartlett Publishers, 2006, 390 pp, ISBN 0-7637-4762-9, $95.00
Available from Elsevier Australia (1800 263 951)

Essentials of Environmental Health is the first book in the new *Essential Public Health* series by Jones & Bartlett Publishers. This series takes a big-picture population health approach to introducing fundamental public health concepts. The series is closely aligned to the core competencies for public health training (USA) and each text in the series has its own companion website.

This text provides a comprehensive overview of the broad field of environmental health and takes a nontechnical approach in order to make the material accessible and interesting for readers who have had little introduction to this field of study. Such an approach, therefore, has many positives and negatives, depending on the reader's perspective. As one might expect, this text covers a broad range of material at a relatively introductory level, but it does so in a user-friendly way. In particular, the text is extremely well illustrated and includes a large number of figures, tables, photographs and explanatory boxes. In fact, it is rare for a page not to contain at least one illustration.

The text consists of 13 relatively detailed chapters that are grouped into the following three parts: background to the field, agents of environmental disease, and applications of environmental health. In part one, the first chapter discusses the significance of environmental health and some of the current drivers for environmental and population change. Chapters 2 and 3 then provide an introduction to epidemiology and toxicology and describe their role in environmental health. To complete this first part of the text, chapter 4 discusses environmental policy and regulation and the role of risk assessment, with this building on the topics covered in chapters 2 and 3. Part 2 then provides detailed descriptions of the following environmental agents of disease: zoonotic and vector-borne diseases, toxic metals and elements, pesticides and other organic chemicals, and ionising and nonionising radiation. Part 3 then moves onto applications of environmental health and discusses water quality, air quality, food safety, solid and liquid wastes, and occupational health. Each of these chapters provides a comprehensive and extremely well illustrated overview to each of these topics. Despite not having a part on global environmental health issues, issues such as global climate change and stratospheric ozone depletion are weaved into the various chapters, including those on air quality and nonionising radiation.

For a text such as this, there can always be some difficulty in retaining a balance between depth and comprehensiveness. This text has, however, managed this balancing act nicely by providing a comprehensive coverage of the broad field of environmental health, while not compromising on the level of detail required to present key facts. In addition, the relaxed writing style and extensive use of illustrations combines to provide an informative and engaging package. If there was one fault with the text, it is that it is somewhat focused on US issues, legislation and management. As such, for Australian readers to get the most out of this text they will need to have some understanding of the local context and be able to relate local issues to the topics covered.

Overall, *Essentials of Environmental Health* is an exceptionally well written and richly illustrated text that provides a comprehensive overview to the broad field of environmental health. I would, therefore, recommend it to undergraduate and postgraduate students who are looking for a very good introduction to environmental health, and to practitioners who are wanting to brush-up on current issues that might be outside their regular field of practice.

Thomas Tenkate
School of Public Health
Queensland University of Technology
Email: t.tenkate@qut.edu.au

Note: over the last few years a number of general, introductory environmental health textbooks have been released, and some of these have been reviewed in this journal. To view and compare these previous reviews, please refer to: volume 2(1), pp. 86-87; volume 3(2), p. 104; volume 4(1), p. 97; and volume 5 (4), pp. 71-72.

Back to TOC

Environmental Health

The Journal of the Australian Institute of Environmental Health

Environmental Health Subscription Form

Annual Subscription Rates: four electronic issues per year *(These rates are subject to change)*

Within Australia (includes GST)

Individual rate	AUD $180.00	☐
Student rate	AUD $100.00	☐
Institutional rate	AUD $300.00	☐
IP Access rate*	AUD $500.00	☐

Overseas (GST does not apply)

Individual rate	AUD $ 160.00	☐
Institutional rate	AUD $ 270.00	☐
IP Access rate*	AUD $ 480.00	☐

**Please include your IP Address below*

IP Address (IP Access rate only): ______________________

Subscriber Contact Details

Name: ______________________

Institution: ______________________

Address: ______________________

______________________ Postcode: ______________________

Telephone: ______________________ Email: ______________________

Payment Details

☐ *Please find a cheque enclosed made payable to AIEH* ***Or***

☐ *Please charge my Credit Card:* ☐ Bankcard ☐ Mastercard ☐ Visa

Card Number: ☐☐☐☐ ☐☐☐☐ ☐☐☐☐ ☐☐☐☐

Expiry Date: ☐☐ / ☐☐

Cardholder's Name: ______________________ Signature: ______________________

Journal Contact Details

Please send completed forms/payment to:

Bernadet Ferraro (National Finance Officer)
Australian Institute of Environmental Health
PO Box 378, Diamond Creek
Victoria 3089 AUSTRALIA
P: (03) 9438 5960
F: (03) 9438 5955

For all other enquiries:

Jim Smith (Editor)
Jaclyn Huntley (Editorial Assistant)
PO Box 225, Kew
Victoria 3101 AUSTRALIA
P: (03) 9855 2444
F: (03) 9855 2442

Back to TOC

Guidelines for Contributors

Manuscripts

Manuscripts should be submitted to Jim Smith, Editor, Environmental Health, PO Box 225, Kew, Victoria, 3101, Australia.

Material will be considered for publication on the understanding that it is original and unpublished work and has not been submitted for publication elsewhere. Authors are responsible for all statements made in the material. Papers accepted for publication become the copyright of the Journal but release for publication elsewhere can be applied for on the understanding that acknowledgment is made to the Journal.

Preparation of Manuscripts

Manuscripts should in general conform to the style outlined in the Australian Government Publishing Service 1994 Style Manual for Authors, Editors and Printers, 5th edn, AGPS, Canberra. Spelling should conform to the Macquarie Dictionary.

Submission of Manuscripts

Articles should not normally exceed 5000 words. Reflections on practice, reports, views and discussion, policy analysis and other material should not normally exceed 3000 words. Authors should forward the manuscript electronically to the editor. A covering letter should identify the author to receive correspondence, including mail and email addresses, telephone and facsimile numbers. Upon acceptance of the manuscript, authors will be requested to submit the document. Manuscripts should generally conform to the following sequence: title page; abstract; text; acknowledgments; endnotes; references; tables and figures, contact details including affiliations and full postal addresses for ALL authors, and telephone, facsimile and email address for contact author.

Title Page

The title page should include the manuscript title, names, institutional affiliations, and academic qualifications of authors (please give complete details including addresses).

Abstract

All articles should include an abstract. The abstract should summarise the paper in 200 words or less. Abstracts can be reprinted in other publications and data bases so that it is important to include the main purpose, content, and conclusions of the article. Up to six key words should be included.

Text

Articles should not normally exceed 5000 words. As the Journal is multidisciplinary, the presentation of material should conform to the standard format according to the particular discipline. Other entries in the Journal, reviews, case reports, editorials, discussion, should not normally exceed 3000 words and are likely to require a different format. Please consult with the editor for guidance.

Tables and Figures

Submit three hard copies of tables and figures as black and white prints preferably 80 x 80 mm but no larger than 180 X 250 mm. Environmental Health will be happy to produce tables and figures if data and type of table or figure required (i.e., bar chart, line graphs) are supplied. If tables or figures are to be reproduced please supply full details of source. Titles and captions of tables and figures should be placed on the actual table or figure. Figures may be from original artwork, photographs, graphs or charts.

Examine all figures carefully to ensure that the data are presented with the greatest possible clarity to help the reader to understand the text. Similarly, determine if a figure would communicate the information more effectively than narrative. Photographs, which disclose their identity, must be accompanied by signed permission.

Each table and figure must be produced on a separate page, double spaced, numbered consecutively, and given a title. Each table and figure must be cited in the text and its position indicated.

Acknowledgments

Acknowledgments should be typed on a separate page, following the text. Where appropriate give credit to grantors, sponsors, technical assistants, and professional colleagues.

Endnotes

Notes which are in addition to references should be used sparingly. They can be numbered in superscript in the text and then listed as Endnotes before the Reference List at the end.

References

References should conform to the Australian Government Publishing Service 1994, Style Manual for Authors, Editors and Printers, 5th edn, AGPS, Canberra. Examples of referencing can be obtained from the Editor.