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Occupational and environmental health in Mauritius: a review of trends and recent studies

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Environmental health—in the general environment and workplaces—is often ignored or undervalued in rapidly developing countries. This paper reports the evolution of a system of legislation and inspection for occupational and environmental health in Mauritius in recent years. It then discusses the findings of empirical studies of air pollution, exposure to vehicular lead and dietary lead intake. It finally discusses the health and safety findings in 16 factories. These studies, findings and legislation have encouraged the training of personnel in environmental health and it is hoped that this will gradually enhance occupational and general population health in the rapidly developing island.

Keywords: occupational health, environmental health, lead intake, safety legislation, Mauritius

Introduction

Mauritius is a small Indian Ocean island of 720 square miles, with a population of around 1.1 million. A British colony from 1810, it gained independence in 1968 to join the Commonwealth of Nations. Historically, the main economic activity of the island has been the cultivation of sugar cane, with export of sugar. However, over the past decade, it has industrialized rapidly, with a dramatic expansion of the manufacturing sector, which now has around 110,000 employees. Mauritius is today the largest textiles exporter in Africa, the third largest in the world, with around 580 textile factories operating. The tourist industry has also expanded rapidly over the past 5 years, Mauritius being a select destination for holidaymakers from Europe, South Africa and south-east Asia. Around 400,000 tourist arrivals are currently expected annually, with this figure continuing to rise steadily. The 1990s have also seen the development of an offshore banking sector in Mauritius.

With the rapid industrialization of the past decade, Mauritian workers are increasingly exposed to a wide variety of new physical and chemical hazards in the working environment, with potential dangers to the general environment. This is common in many rapidly industrializing countries. There is, in Mauritius at any rate, a growing awareness of occupational and environmental health. Two main departments in the government are concerned with health and safety. The Ministry of Health has an Occupational Health Unit staffed by four trained occupational physicians. There are also two or three occupational physicians operating in the private sector. The Ministry of Labour's Factory Inspectorate primarily has responsibility for safety at work.

Recently, a number of legal measures have been taken to enhance the health and safety of employees and for general environmental preservation. In 1988, the Occupational Safety, Health and Welfare Act was passed. This is a wide-ranging piece of legislation which aims to promote safety awareness, safe organization and performance, and to make occupational health and safety the concern of both employers and employees. In addition to various health and safety provisions, the Act also requires employers of more than 100 workers to appoint a Health and Safety officer. Training for such a role is provided by a 2 year part-time course at the University of Mauritius, leading to a Diploma in Occupational Health and Safety.

In 1991, the Environment Protection Act was

passed in the National Assembly. This wide-ranging legislation aims to provide a legal framework and mechanism to protect the natural environment, to plan for environmental management and to co-ordinate the interrelations of environmental issues. Some key aspects of the Environment Protection legislation include the requirement for a wide range of developments to be subject to an Environmental Impact Assessment; powers of official intervention in the event of environmental spills and emergencies; setting national environmental standards for water, noise and effluents; the enforcement of the environment standards, and compliance with environmental law by various authorities.

Apart from these legal developments, the Ministry of Labour participated over the period 1990–1994 in the ILO-FINNIDA African Safety and Health Project. This project led to various training activities in Mauritius and in the region, and the setting up of a Labour Information Centre which is part of the international ILO-CIS network. Through this centre, current and regularly updated information on chemicals, health and safety legislation is available on CD-ROM.

Over the period 1991–1993, a number of research projects were conducted in health and environment in Mauritius. These projects were in the context of a larger Environmental Investment Programme, and were carried out by the Norwegian Institute for Air Research, and COWI Consult of Denmark, with the support of the Occupational Health Unit, Ministry of Health and Factory Inspectorate, Ministry of Labour in Mauritius. The projects involved surveys of a range of topics including air pollution sources and their impact on air quality; population exposure to vehicular lead and a pilot study of dietary lead intake. The second element was a review of health and safety in 16 factories. The studies illustrate the ways in which rapidly developing islands can conduct well-defined reviews of aspects of environmental health.

The air pollution survey

Air pollution in Mauritius is primarily from road traffic, with significant exposure to vehicle emissions near busy roads. Industrial sources include emissions from the sugar factories, from the burning of sugar cane foliage, and other various industrial units. The assessment of air pollution impact in the study was based on vehicle fleet statistics, traffic data, meteorological data and measurement of air pollutants. Mauritius used leaded petrol (0.7–0.8 g l^{-1} lead) until 1993, after which the amount of lead in petrol was halved.

Routinely collected data on traffic distribution and vehicle movement were available for 13 sites (road crossings and roundabouts) and seven additional sites, including road sections where air pollutant measurements were carried out. In the capital, Port Louis, several street sections had traffic in excess of 15,000 per day, with some exceeding 20,000 per day. The traffic on the main highways from the capital in the north and south is about 26,000–28,000 vehicles per day. Outside the main urban areas, the number of vehicles per day on road sections is fewer than 5000. The vehicular fleet is around 50% cars, 43% light duty vehicles/vans, 5% trucks and 1.5% buses.

Measurements of PM (particulate matter), lead and nitrogen dioxide (NO_2) were taken over an 8 week period (August–October 1992) at four key sites, two in Port Louis and at two other urban sites. PM measured was $PM_{2.5}$ (mainly combustion particles from car exhaust) and PM_{10} (which also includes wind-blown dust particles). The results showed two anomalous periods of especially elevated pollution at all locations. These periods of 4 days' duration each corresponded to very low wind velocities and calm nights. These periods may have corresponded with abnormal readings, as a result of climatological variation, which do not reflect the real situation. With the exception of the episodes with high pollution, the PM concentration was surprisingly equal at all four stations, with a PM_{10} level of 40–60 mcg m^{-3}, and a $PM_{2.5}$ level of about 10 mcg m^{-3}. This indicated that a significant contribution to PM concentration came from sources *other* than road traffic. This was further supported by the fact that soot predominated on the filters (indicating another combustion source), and the observation that the fraction filters also contained mineral particles.

PM measurements carried out near an agricultural area gave readings of $PM_{2.5}$ 10–20 mcg m^{-3} and PM_{10} 50–70 mcg m^{-3}. This result suggested that the regular practice of burning foliage in sugar cane fields may be a considerable source of pollution, leading to a concentration of PM_{10} of approximately 50–70 mcg m^{-3}. Air quality guidelines (AQG), based on health effects, recommend an upper PM_{10} limit of 70 mcg m^{-3} (WHO, 1987) and 150 mcg m^{-3} (Mauritian Guidelines). At two of the urban sites, the WHO AQG were exceeded on more than 50% of the period of the study.

Nitrogen dioxide is also an air pollutant, resulting from vehicle emissions (Samet and Utell, 1990), and concentrations were fairly low, lower than in Western European urban areas. The lead fraction of particulate matter collected was also analysed, and it also supported earlier evidence that sources other than car exhaust contribute to PM concentrations. The 2 month average lead-in-air concentration in a high traffic area of the capital was estimated at 0.5 mcg m^{-3}, which is less than the proposed AQG for Mauritius (1.5 mcg m^{-3} as a 3 month average). Carbon mon-

oxide is also present in exhaust gas of vehicles and may produce toxic systemic effects (WHO, 1979, 1987). Carbon monoxide concentrations on various occasions during the survey period indicated that this gas constitutes a moderate air pollution problem. Near the busier roads, concentrations approach and exceed WHO and Mauritian AQGs (respectively, 30–40 ppm for a 1 hour average and 10 ppm for an 8 hour average) on the most polluted days.

Industrial sources of air pollution

A significant source of pollution is the burning of sugar cane leaves in the fields, and the bagasse in the factories, leading to high emissions of fly ash, soot and volatile organic compounds during the harvest season (June–December). Other pollution sources include tanneries and fish processing plants which cause localized odour problems; chemical factories, rolling mills; stone crushing plants, which cause significant dust pollution in their immediate vicinity; eight open landfills which are often burning, leading to malodorous organic emissions. Analysis of particulate matter in the vicinity of two sugar cane factories has also shown wide distribution of particulates, with 65% or more being in the respirable fraction (<10 μm aerodynamic diameter).

Energy production in Mauritius is based partly on oil-fired power plants which are a source of sulphur dioxide pollution. Sulphur dioxide may increase morbidity and mortality in the population, especially those with respiratory problems (WHO, 1987). During the survey, dispersion calculations of short-term averaged concentration of sulphur dioxide were carried out. For two major power stations, SO_2 emission data were calculated based on a sulphur content of 3.5% and an hourly oil consumption of 7250 l and 5130 l, respectively. The emissions obtained were 450 kg h^{-1} SO_2 and 320 kg h^{-1} SO_2, respectively. Depending on climatological factors (mainly wind direction), maximum hourly SO_2 concentrations between 500 and 1500 mcg m^{-3} can occur at distances between 300 and 1000 m of one of the stations. For the other station, maximum hourly SO_2 concentrations could reach 700–900 mcg m^{-3}. These data are significantly higher than the WHO guidelines for air quality, which recommend 350 mcg m^{-3}, as a maximum hourly SO_2 concentration.

Emission data for dust from one typical sugar factory showed that during normal operating conditions, including wet scrubbing, maximum hourly dust concentrations up to 5–7 mcg m^{-3} might occur between 500 and 2500 m from the source, depending on climatological conditions. When the scrubber is not functioning, maximum hourly dust concentrations of 80–100 mcg m^{-3} may occur at distances of 1–5 km from the source. These values are 5 and 80%, respectively, of the daily averaged WHO guidelines for PM_{10}. The highest PM concentrations measured downwind for sugar factories gave the following data: PM_{10} = 167 mcg m^{-3}; TSP = 259 mcg m^{-3}. This may be of some concern, especially the combustion particles containing partly burnt organic material. It is also of note that 7–10 of the sugar factories are located so that they regularly expose local population centres to their emissions.

Overall, the measurements and dispersion calculations showed that, in Mauritius, some point sources cause air pollution problems locally, so that Air Quality Guidelines are exceeded. The practice of burning sugar cane during the sugar harvest season also leads to a general PM concentration level in Mauritius of 50–70 mcg m^{-3}, compared with WHO recommended guidelines of 70 mcg m^{-3}.

Population exposure to vehicular lead

The Mauritian population is exposed to various sources of environmental lead, including vehicle emissions, lead in paint, and from industrial sources. To evaluate the lead burden of the Mauritian population, 312 people in selected occupational and residential subgroups were chosen for preliminary sampling. Blood samples from these individuals showed a high blood lead in certain population groups in Mauritius, such as traffic policemen, paint sprayers and petrol station attendants, with levels averaging 12–15 mcg dl^{-1}. However, these levels were far from the levels needing detoxification in adults. Traffic pollution seems to contribute only slightly to higher concentrations of lead in blood, especially for women.

There were very high blood lead results detected in the vicinity of a lead battery factory on the outskirts of the capital city. Four children who spend all their after-school hours and holidays with their grandmother living adjacent to the battery factory were found to have blood lead in the range 30–66 mcg dl^{-1}. This is very high, at a level harmful to the developing brain of young children. In children, blood levels as low as 10 mcg dl^{-1} have been associated with decreased intelligence and impaired neurobehavioural development (Davis and Svendsgaard, 1987; Mushak *et al.*, 1989). Other effects beginning at these low blood leads include decreased stature and growth (Schwartz *et al.*, 1986; Bornschein *et al.*, 1986; Shukla *et al.*, 1989), decreased hearing acuity (Schwartz and Otto, 1987), and decreased ability to maintain a steady posture (Bhattacharya *et al.*, 1988). In 1985, the Centre for Disease Control in the USA set a threshold level for action at 25 mcg dl^{-1}, which is being reviewed to 10 mcg dl^{-1} (Centers for Disease Control, 1991).

Following the high blood lead found, these four children were admitted to hospital for chelation therapy and are still under follow-up treatment. The government authorities took action to prohibit certain practices within the lead battery factory, and recommended relocation of the factory. Furthermore, it is understood that the families of the four children are suing the management of the battery factory, and other concerned parties for compensation, arguing that the health of the children has been irreparably damaged.

Dietary lead intake in Mauritius

This study was carried out primarily for the Ministry of Health by a consultant from Denmark. Samples of vegetables, fruit and soils were collected in traffic-exposed areas and control areas. Priority was given to collection of leafy vegetables as they were expected to exhibit the highest lead concentrations through atmosphere deposition on the leaf surface. The samples were oven-dried in Mauritius before despatch to Denmark for analysis. This exercise was accompanied by a limited questionnaire survey to enable a food consumption model to be established. From these two sets of data, the potential dietary lead intake for children and adults was estimated.

The results showed generally elevated levels of lead in leafy vegetables from the traffic-exposed areas, compared with control areas. In unwashed leafy vegetables, the lead concentration was 4–13 times higher in traffic-exposed areas as compared with control areas. The soil concentration of lead was also within the wide normal range of 2–200 mcg g^{-1} (internationally, the average normal value is 10 mcg g^{-1}). In an industrial suburb of the capital, lead concentration was somewhat elevated (72 mcg g^{-1} dry weight) though still within the normal range. However, a soil sample taken in the vicinity of the lead battery factory showed levels of more than 2000 mcg g^{-1}.

The data indicated that the adult dietary intake was significantly below the provisional tolerable weekly intake (PTWI) established by WHO/FAO. For children, account must be taken of their unintentional ingestion of soil and inhalation of dust. International data suggest a soil/dust intake in children of between 0.2 and 2 g per day (WHO, 1986). On this basis, the weekly lead intake for children in control areas is still less than the PTWI. However, the PTWI may be exceeded for children in the industrial suburb of the capital, and is certainly exceeded for the few children near the lead battery factory.

Review of health and safety

This third project under the Environmental Investment Programme was carried out by a Danish consultant with support from officers of the Ministry of Health and Ministry of Labour in Mauritius. Sixteen companies were selected on the basis of being 'major hazard places of work', and were visited to evaluate the working environment and data on occupational injuries. The national data collection system regarding occupational injuries and occupational diseases was also analysed. The aim of this survey was to use the approach to these 16 'high risk workplaces' as a model, which would hopefully be extrapolated to monitoring of workplaces in other industries. Individual reports for each company were prepared and made available to the authorities and management of the companies.

In most companies, there were deficiencies with regards to the working environment, owing mainly to inefficient storage, handling, and therefore leading to possibly harmful exposure to chemicals. One particular battery factory was pinpointed as having a very poor working environment, with a serious risk for the workers of contracting occupational diseases. Overall, it was felt that the problem was really a lack of knowledge and experience as to how to improve the working environment, rather than reluctance to do so. Many companies used potentially hazardous chemicals in the production processes. In most companies, material safety data sheets were not available. In three-quarters of the companies, sufficient knowledge of the potential risk related to the use of chemicals was lacking, and therefore adequate instruction in the safe handling and storing of chemicals was not given. In practically all the companies, there was no possibility of monitoring exposure to the chemicals.

As in many other countries at similar stages of industrial development, very often the risks of accidents were prevalent at an unsatisfactorily high level, often owing to poor ergonomics and illumination, inadequate maintenance and housekeeping. Only a few of the companies had a written safety policy or a professional and preventive approach to health and safety at work. Generally, senior management did not participate actively in health and safety at work, and the unions also generally gave low priority to health and safety matters. In some of the companies where personal protective equipment (PPE) was distributed to the workers, the PPE was unsuitable or used inappropriately (owing to lack of instruction and motivation), or was not stored, cleaned or maintained satisfactorily. Therefore, this survey highlighted a number of shortcomings in the health and safety situation in Mauritius, which are now, hopefully, being addressed.

Overview and conclusion

There have been many significant developments

in the areas of occupational and environmental health and safety in Mauritius over the past 7 years. As a result of new legislation, a number of detailed technical surveys have highlighted problem areas which need to be addressed. However, there are still major obstacles and difficulties. Despite two pieces of comprehensive legislation, enforcement is still patchy, owing to shortage of appropriately trained and motivated staff and lack of equipment. For example, in many industrial units, despite the presence of a health and safety officer (to comply with the law), there have been no significant improvements in the working environment. The Ministry of Environment is also inadequately staffed to assume the major responsibilities and carry out the monitoring roles required of it following the new Environmental Protection Act 1991. The surveys on atmospheric pollution and environmental lead have also pinpointed areas which need further study (for example with larger populations) to evaluate the problems.

Nevertheless, Mauritius does have the appropriate staff and experts to enhance the state of occupational and environmental health. However, many have been working in relative isolation, in different departments or in the private sector. If appropriate mechanisms could be found to pool expertise in the island, with some additional resources from international agencies, it should be possible, eventually, to raise occupational and industrial health in Mauritius to the standard of the major industrialized countries.

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