J. Soc. Occup. Med. (1991) **41**, 133–136

Aspects of Occupational Health in the Sugar Cane Industry

H. N. PHOOLCHUND
Occupational Health Department, London Borough of Ealing, London, UK

Summary

Workers in developing countries face as many, if not more, work-related health problems as their counterparts in industrialized nations. This paper concentrates on occupational health problems in the sugar industry, which exists in 40 countries, mostly in the Third World. Sugar cane workers have a high level of occupational accidents and are exposed to the high toxicity of pesticides. They may also have an increased risk of lung cancer, possibly mesothelioma. This may be related to the practice of burning foliage at the time of cane-cutting. Bagassosis is also a problem specific to the industry as it may follow exposure to bagasse (a by-product of sugar cane). The workers may also be affected by chronic infections which reduce their productivity. The legal framework for their protection is often inadequate. In conclusion, areas of future research are suggested.

Introduction

The cane sugar plant (*Saccharum officinarum*) is grown in 40 countries, mainly from the Third World. It is cultivated in plantations, with stalks reaching 6–7 metres in height. The stalk is segmented by joints and contains a sap from which sugar is processed.

The cane cutting season lasts for six months of the year, with most of the world's sugar cane being cut by hand. Harvesting must take place soon after the last growth period of the cane to maximise sugar content (10–17 per cent of total weight). It is common practice to burn the foliage, either before cutting the stalks (to make access easier for the cutter), or after mechanical harvesting (e.g. in Southern USA).

After manual cutting of the stalks into suitable lengths they are transported to the factory for sugar extraction. The cane stalks are crushed by roller mails to extract the juice, which is gradually concentrated by a stepwise process of vacuum boiling and evaporation to produce crystalline sugar. The residual fibrous material is called bagasse and has many secondary uses.

Accidents and Injuries

It is difficult to compare data relating to occupational accidents in different countries as, where available, they would have been collected using different criteria[1].

Under-reporting of work place accidents is well known in developed countries, and the problem is even more severe in developing countries, especially in the widely dispersed agricultural sector[1]. Because of this, the International Labour Organisation Annual Yearbook on Labour Statistics only reports data on fatal accidents.

Nevertheless, available data suggest a high level of accidents in the sugar industry. A study from Puerto Rico[2] reported a level of 15000 injuries a year for a working population which fluctuated from 21000 in October to 50000 in June. Data from Mauritius[3] showed a level of >10000 injuries per year since 1982, for a working population of 44000. A substantial proportion of the injuries occur during hand cutting of the cane. The stalk is usually grasped by the left hand while the right hand wields a fairly heavy machete to do the cutting. In the study from Puerto Rico[2], the accidents in more than 50 per cent of the cases were due to loss of control of the machete, so that it could not be directed at the target. Other causes of accidents were hitting oneself with the machete, loss of balance and falls. Suchman and Munoz[2] also reported on the attitude of the workers to accident prevention and their responses to the introduction of a protective glove. This glove had a series of chains embedded on the back to prevent injury if the machete struck the hand. Four out of five workers believed that accidents could be prevented, and two out of three felt that one could learn to prevent accidents. The glove was generally welcomed, with 86 per cent acceptance within two/three days.

Noise

Noise is a potential hazard at various points in the sugar cane manufacturing process. In the cane fields noise can reach unsafe levels during mechanical harvesting, particularly on rocky terrain. In the sugar mills there are a number of locations where noise is excessive.

1. At the point of arrival by tractor where the cane stalks are transferred by overhead cranes onto rotating cane knives, to be cut into chips 1–2 feet long. This process normally takes place in the open where there is no additive effect of reverberation or sound reflection. 2. Within the factory, where the cane chips are moved by conveyor belts to the roller mills to be crushed. 3. In the vicinity of the power plant of the factory (fuelled by oil or electricity.)

Much of the machinery in sugar mills in developing countries was manufacturing before noise-reduction was an important aspect of design. Noise reduction at source by modification of such existing machinery is expensive and time-consuming. Good maintenance and lubrication is an effective means of reducing noise. Another option used is noise insulation by enclosure, using locally produced insulation material (e.g. from bagasse, itself a byproduct of the sugar industry). Personal hearing protection is normally the last resort as adequate compliance is difficult to achieve.

Pesticides

These chemicals are widely used in the industry, and the types used include organophosphorus compounds,

0301-0023/91/030133-04

carbamates and pyrethroids. Herbicides are used in weed control, which is particularly important to eliminate competition in early growth stages of the crop. The problems associated with pesticide use in developing countries have been well documented[4-9]. Although 20 per cent of pesticide use occurs in developing countries, 99 per cent of cases of pesticide poisoning occur in these regions[10]. The World Health Organisation estimates that there are 500 000 cases of pesticide poisoning worldwide every year, with more than 9000 deaths[11].

Sugar cane workers are as much at risk of pesticide poisoning as are other agricultural workers. The factors contributing to the high level of occupational pesticide poisoning are: lack of awareness of the toxicity of these agents; insufficient information about appropriate use of pesticides[12]; inappropriate techniques in dilution, mixing and spraying, e.g. mixing with teaspoons or bare hands[12]; inadequate use of protective clothing; inappropriateness of protective equipment to tropical conditions; haphazard observation of the safety interval after spraying.

Sugar Cane and Lung Cancer

There are reports of an increased risk of lung malignancies in sugar cane workers. In Southern Louisiana, USA, where sugar cane has been the predominant industry in the 1930s, an excess mortality due to lung cancer has been shown. In a case referent study of lung cancer deaths, Rothschild and Mulvey[13] found a relative risk of lung cancer mortality in sugar cane workers of 2.4 (95 per cent confidence limits 1.7–3.6) after adjustment for smoking. Furthermore, sugar cane workers who died of lung cancer had worked for longer in the industry than those who did not develop lung cancer. A pathological diagnosis was obtained in 205 out of the 284 cases of lung cancer. The distribution of histopathological types was similar to that of lung cancer deaths in those not employed in the industry. However, two sugar cane workers had mesothelioma with no apparent exposure to asbestos.

Das *et al.* reported 5 cases of mesothelioma associated with sugar cane farming in a rural community in India[14]. The 5 cases presented between 1974 and 1976 with chest symptoms. Surgical excision was performed and pathological diagnosis obtained in all 5 cases. Four of the patients were directly involved in sugar cane cultivation; the other patient was a chemist in a local sugar factory.

There is extensive evidence of mesothelioma associated with agents other than asbestos[15]. A group of naturally occurring fibrous silicates, known as zeolites, have been implicated as causing mesothelioma in agricultural communities. Following an 'epidemic' of mesothelioma in Karain, Turkey[16], dust sampling showed 'respirable' fibres of erionite, a zeolite, and no evidence of asbestos exposure. This leads to the hypothesis of an association between erionite inhalation and mesothelioma. Zeolites are present in the soil in many regions of the world, though only in a few situations have fine erionite fibres been identified, e.g. in Oregon, Nevada, Utah. Samples of Oregon erionite have produced a 100 per cent rate of mesothelioma in animals after inoculation and inhalation[17].

It is therefore possible that the cases of mesothelioma in sugar cane workers are related to unidentified zeolites in the soil. An alternative theory is that the burning of sugar cane leaves before or after harvesting releases potentially carcinogenic material. Sugar cane leaves contain biogenic silica, which is also found in a number of other plant species[18]. Newman has also shown experimentally, that cane leaf residue from ashing and acid digestion contains silica fibres of diameter 0.85 μm and length 10–300 μm[19].

Gravimetric sampling has been done in the vicinity of a sugar cane field during burning operations[20]. Sampling equipment was placed at various locations to take account of wind direction, and in the breathing zone of workers involved in burning and cutting. Inorganic fibres, as confirmed by an energy dispersive X-ray analyser, were found in some of the samples collected on the workers. Elemental analysis showed that they contained primarily silicon in silica or silicate fibres of dimensions as follows: length 3.5–65 μm (mean 12 μm), width 0.3–1.5 μm (mean 0.6 μm).

Fibre dimensions are thought to be a determining factor in the causation of mesothelioma. Wagner[17] suggested that inhalation of all mineral fibres of diameter approximately 0.25 μm and length >10 μm may be associated with pleural and peritoneal mesothelioma. It is therefore possible that fibres of biogenic silica from sugar cane with comparable dimensions are similarly implicated.

Bagassosis

After extraction of sugar cane juice, the residual fibre is known as bagasse. This material has found uses in insulation, as fuel, and in paper manufacture. The fibre is usually compressed into bales which are bound by metal wire and stored for drying for up to 12 months. After drying they are de-stacked and inner layers further compressed prior to shipment or transfer elsewhere for other uses. During the de-stacking process workers are exposed to dried, old bagasse fibres which may be heavily laden with fungal and bacterial organisms.

Such exposure may lead to a form of extrinsic allergic alveolitis, bagassosis. The condition may present insiduously with increasing dyspnoea and cough, or acutely after an unusually heavy exposure. On examination, there are usually basal crackles (generalized in severe cases). Chest X-ray may be normal in the early stages, followed by the appearance of fine micronodular shadowing (predominantly basal), and a return to normality after an average of eight weeks. In the acute illness, lung function tests show a decrease in FEV_1, FVC, TLC, transfer factor and residual volume[21]. After recovery, lung function may return to normal. Further exposure does not necessarily lead to recurrence. If it does, the worker is probably prone to further episodes which would be more severe and disabling[22]. A change of employment would be advisable after a recurrence.

The causative agent has been identified by Lacey[23] as being *Thermoactinomyces sacchari*. It has been estimated that bagassosis may develop in up to 50 per cent of those exposed to mouldy bagasse[24]. Cases have been reported in those exposed in sugar mills[25] and those with transient mild exposure, e.g. in the manufacture of boards from bagasse in the UK[26]. Exposure prior to symptoms may vary from 4 months to 12 years[25]. Asymptomatic workers have been shown to have reduced FEV_1 and FVC in a survey of 170 bagasse workers by Hearn[25]. On further follow-up, this group's lung function tests reverted to normal, 2 years after cessation of exposure[27].

Following recurrent episodes of bagassosis, a worker may eventually develop pulmonary fibrosis as with farmer's lung. There have been a number of reports of pulmonary fibrosis following bagassosis[28], with one paper suggesting that a single episode of bagassosis may be enough to cause lung impairment[27]. In 1962, bagassosis became a pneumoconiosis listed for compensation in Louisiana, USA[22].

In the 1970s, numerous methods were adopted to reduce microbial growth in the storage of bagasse. In some mills the raw bagasse was stored in loose and unpacked form, rather than in packed bales which favoured the growth of actinomycetes. The mounds of bagasse were continually moistened by means of an automatic sprinkler. This kept the level of moisture to 50–60 per cent as compared to 15–30 per cent in packed bales (Actinomycetes grow more vigorously at the lower moisture level). It has also been suggested that adding 1 per cent proprionic acid to fresh bagasse limits the growth of the fungi.

The duration of storage also tends to be less than before (5 months now compared to 9 months previously). Wherever possible, the shredding of crude bagasse is done in the open, where ventilation is good. These practices, together with the use of local exhaust ventilation and machinery enclosure (where practical) have contributed to a reduction in the incidence of bagassosis in Louisiana, USA[29]. However, information is lacking as to whether work practices have similarly altered in other cane producing areas of the world. The additional use of high efficiency respirators would also be beneficial; but even if they were available, it would be difficult to persuade workers to use such protection in the hot, humid climates.

Chronic Infections and Working Capacity

Workers in the sugar industry in developing countries are exposed to a wide variety of infestations and infectious diseases. As well as leading to increased morbidity and mortality, these diseases are severely debilitating, and make those affected more susceptible to the effect of toxic chemicals encountered at work[30,8]. This is the 'double burden' of workers in developing countries[30]. Their economic output is also reduced. Malaria, Chagas' disease, yellow fever, schistosomiasis, leishmaniasis, can all lead to reduction of work capacity[31].

Malaria may cause a generalized aesthenia, with reduced efficiency, even in between outbreaks. Chagas' disease has a similar effect when the digestive and cardiovascular systems are affected. Schistosomiasis is endemic in 70 countries worldwide, many of them sugar cane producers. Its effect on work output has been extensively studied[32–36].

In a survey of 200 sugar cane workers in an irrigated estate in Northern Tanzania[32] those infected with schistosomiasis had significantly higher levels of absenteeism, were more prone to malaria, and required medical attention more often. In the same location, another study[33] looked at the effect of chronic schistosomiasis on productivity, using the level of bonus earnings as a parameter. It was found that infected sugar cane workers earned 11 per cent less in bonuses than uninfected ones. The author estimated that a 3–4 per cent difference in productivity was attributable to chronic infection.

Legislative Protection

Legal provisions for the protection of the health and safety of sugar cane workers are of variable standards, usually inadequate. Many of the producing countries are former British colonies, and have an out-dated health and safety legislation dating back to colonial times. Enforcement is also inadequate because of a shortage of trained personnel and factory inspectors[37]. In contrast, Latin American countries have regulations which theoretically give adequate worker protection. However, implementation and enforcement is controlled by different ministries and institutions, with duplication of activities and increasing bureaucracy. Some countries, (e.g. Brazil, Argentina) still maintain the concept of a security subsidy, with a percentage of the salary paid as a supplement for working in an unhealthy environment[30]. This does not encourage good occupational health and safety.

Agricultural workers are the most underserved with regard to occupational health resources[30,38]. Overall, there is a spiral of lack of resources, under-monitoring and under-reporting of occupational diseases, which gives the planners the impression that problems are non-existent.

Internationally, there is some attempt to acknowledge the poor working conditions of sugar cane workers. The International Sugar Agreement, an administrative agreement between 50 countries which import and export cane sugar, contains a clause which states that members should 'ensure that fair labour standards are maintained in their respective sugar industries'[39]. However, there is no machinery to monitor these standards, or impose sanctions, so the effectiveness of this clause is limited.

The International Labour Organisation is also a source of standards which provides some protection for workers in developing countries. The Annual International Labour Conference brings delegates from the 151 member states, and conventions adopted by the conference are binding on member states which have ratified the convention[40]. Since its foundation, the ILO has adopted 162 conventions, 40 per cent of which are relevant to occupational health. The ILO has a system of monitoring which, in 1983, led to an enquiry into the employment of Haitian workers on sugar plantations in the Dominican Republic. As a result of this enquiry, a number of recommendations were made which would substantially improve the working conditions of these Haitian workers.

In many developing countries with inadequate health and safety expertise, the ILO conventions could be an instrument for worker protection, provided they are ratified.

Conclusion

Workers in the sugar cane industry and other agricultural sectors in developing countries face some common occupational health problems, e.g. the high level of accidents and injuries at work, the hazards of pesticide exposure. Whereas there is an increasing awareness of pesticide toxicity, addressing the issue of accidents is more complex because of weaknesses in the infrastructure of reporting and legislation.

More specific to the sugar cane industry is the suggestion that fibres from sugar cane, after burning of foliage, may be carcinogenic. This requires further investigation with carcinogenicity studies, e.g. adminis-

tration to animals of fibres from burnt sugar cane by inhalation or pleural administration. Additional evidence from well designed epidemiological studies is also required.

Acknowledgement

This article is based on a dissertation submitted for the Membership of the Faculty of Occupational Medicine, Royal College of Physicians of Ireland.

REFERENCES

1. Gomez MR. Preliminary observations regarding occupational accidents and diseases in the Caribbean and Central America. *Unpublished report* 1981.
2. Suchman EA, Munoz RA. Accident occurrence and control among sugar cane workers. *J Occup Med* 1967; **9**: 407–14.
3. National Pension Fund (Mauritius). *Return of Notice of Accidents 1986–1988* (Unpublished report).
4. Rosival L. Pesticides. *Scand J Work Environ Health* 1985; **11**: 189–97.
5. Senewirante B, Thambipillai S. Pattern of poisoning in a developing agricultural country. *Br J Preventive Social Med* 1974; **28**: 32–6.
6. Jeyaratnam J, Lun KC, Phoon WO. Survey of acute pesticide poisoning among agricultural workers in four Asian countries. *Bull WHO* 1987; **65**(4): 521–7.
7. Jeyaratnam J, Seneviratne RS, Copplestone JF. Survey of pesticide poisoning in Sri Lanka *Bull WHO* 1982; **60**(4): 615–9.
8. Copplestone JF. Pesticide Exposure and Health in Developing Countries. In: Turnbull GH. ed. *Occupational Hazards of Pesticide Use*, London: Taylor & Francis, 1985; 65–77.
9. Baker EL, Zack M, Miles JW, *et al.* Epidemic Malathion poisoning in Pakistan malaria workers. *Lancet* 1978; **1**: 31–3.
10. Jeyaratnam J. Health problems of pesticide usage in the Third World. *Br J Indust Med* 1985; **42**: 505–6.
11. Xue Shou-Zhen. Health Effect of Pesticides: A review of epidemiologic research from the perspective of developing nations. *Am J Indust Med* 1987; **12**: 269–79.
12. Fagoonee I. Pertinent Aspects of Pesticide Usage in Mauritius. *Insect Sci Appli* 1984; **5**(3): 203–12.
13. Rothschild H, Mulvey J. Increased risk for lung cancer mortality associated with sugar cane farming. *J. Natl Cancer Inst* 1982; **68**: 755–60.
14. Das PB, Fletcher AJ, Deodhare SG. Mesothelioma in an agricultural community in India: A clinicopathological study. *Aust NZ J Surg* 1976; **46**: 218–26.
15. Pelnar PV. Further evidence of non-asbestos related mesothelioma. *Scand J Work Environ Health* 1988; **14**: 141–4.
16. Baris YI, *et al.* An outbreak of pleural mesothelioma and chronic fibrosing pleurisy in the village of Karain/Urgup in Anatolia *Thorax* 1978; **33**: 181–92.
17. Wagner JC. Mesothelioma and mineral fibre. *Cancer* 1986; **57**: 1905–11.
18. Newman RH. Asbestos-like fibres of biogenic silica in sugar cane. *Lancet* 1983; **2**: 857.
19. Newman RH. Fine biogenic silica fibres in sugar cane. A possible hazard. *Ann Occup Hyg* 1986; **30**: 365–70.
20. Boeniger M, Hawkins M, Marsin P, *et al.* Occupational exposure to silicate fibres and PAHs during sugar cane harvesting. *Ann Occup Hyg* 1988; **32**: 153–69.
21. Weill H, Beuchner HA, Gonzalez E, *et al.* Bagassosis. A study of pulmonary function in 20 cases. *Ann Int Med* 1966; **64**: 737–47.
22. Beuchner HA, Aucoin E, Vignes AJ, *et al.* The resurgence of Bagassosis in Louisiana. *J Occup Med* 1964; **6**: 437–41.
23. Lacey J. Themoactinomyces Sacchari sp; a themophilic actinomycete causing bagassosis. *J Gen Microbiol* **66**: 327–38.
24. Morgan W, Seaton A. *Occupational Lung Diseases*, 2nd edn, Philadelphia: W.B. Saunders, 1984; 590–1.
25. Hearn CED. Bagassosis, an epidemiological environmental and clinical survey. *Br J Indust Med* 1968; **25**: 283–92.
26. Hargreave FE, Pepys J, Holfold-Stevens V. Bagassosis. *Lancet* 1968; **1**: 619–20.
27. Miller GJ, Hearn CED, Edwards R. Pulmonary function at rest and during exercise following bagassosis. *Br J Indust Med* 1971; **28**: 152–8.
28. Beuchner HA. Bagassosis: A true pneumoconiosis. *Indust Med Surg* 1962; **31**: 311–14.
29. Lehrer SB, Turer E, Weill H, *et al.* elimination of bagassosis in Louisiana paper manufacturing plant workers. *Clin Allergy* 1978; **8**: 15–20.
30. Sandoval H. Occupational health in Latin America and The Caribbean. Status, legislation, organisation. *East African Newsletter on Occupational Health and Safety* 1989; Suppl 3: 43–6.
31. Forratini OP, Nogueira DP. Effects of tropical disease on working capacity. *J Occup Med* 1977; **19**: 485–6.
32. Foster R. Schistosomiasis on an irrigated estate in East Africa. Effects of asymptomatic infection on health and industrial efficiency. *J Trop Med Hyg* 1967; **70**: 185–95.
33. Fenwick A, Figenschou BH. The effect of schistosoma mansoni infection on the productivity of cane cutters on a sugar estate in Tanzania. *Bull WHO* 1972; **47**: 567–72.
34. Wright WH. A consideration of the economic impact of schistosomiasis. *Bull WHO* 1972; **47**: 559–66.
35. Collins KJ, Brotherwood RJ, Davies CT, *et al.* Physiological performance and work capacity of Sudanese cane cutters with schistosoma marsoni infection. *Am J Trop Med Hyg* 1976; **25**: 410–21.
36. Barbosa FS, Pereira Da Costa DP. Incapacitating effects of schistosoma marsoni on the productivity of sugar cane cutters in North Eastern Brazil. *Am J Epidemiol* 1981; **114**: 102–11.
37. Baloyi RS. Occupational Health in Africa – Status, legislation and Organisation. *East African Newsletter on Occupational Health and Safety* 1989; Suppl 3: 35–7.
38. Choudry AW. Occupational health in agriculture. *East African newsletter on Occupational Health and Safety* December 1989; **3**: 16–9.
39. Anonymous, Article 28: *Labour Standards*, International Sugar Agreement 1984. London HMSO Miscellaneous No. 10, 1985; page 15.
40. Kliesch G. The ILO Safety and Health programme. In:Kurppa K, *et al.* eds, *Proceedings of the Regional ILO – Finnish Symposium on Occupational Health and Safety in East Africa.* Helsinki: Institute of Occupational Health, 1987; 13–20.

Requests for reprints should be addressed to: Harry N. Phoolchund, Occupational Health Department, Civic Centre, London Borough of Ealing, 12–14 Uxbridge Road, London W5 2HL, UK.