Bull. Environ. Contam. Toxicol. (1991) 46:74–78

Environmental Contamination and Toxicology

Contamination of Soils and Sediments in the Vicinity of a Mercury Recovery Plant

P. Johnston,[1] R. Stringer,[1] M. C. French,[2] and J. Vallette[3]

[1]Greenpeace QMW, School of Biological Sciences, Queen Mary and Westfield College, University of London, London E1 4NS, U.K. [2]Institute of Terrestrial Ecology, Monks Wood Research Station, Cambridgeshire, PE17 2LF, U.K., and [3]Greenpeace International, Keizersgracht 176, 1016 DW, Amsterdam, Netherlands

The value of mercury metal and its salts means that recovery from exhausted catalysts and electrical equipment is economically attractive. One such recovery plant is operated at Cato Ridge, Natal, South Africa. The process involves heating the wastes and container in an oil feed furnace at 900°C. Mercury is recovered from a sludge containing mercury and soot. Processing of the waste involves the use of evaporation ponds and process residues are landfilled on the site. There appears to be no direct discharge from the plant, but a groundwater spring at the foot of the hill under the factory is the source of the local river.

The river is used extensively by the local community for water supplies, livestock watering, washing and bathing. Some fishing also appears to be practiced. Recently, unconfirmed reports have suggested that mercury contamination in the area is significant. Accordingly, environmental samples were obtained from the area in order to assess this.

METHODS AND MATERIALS

Samples were obtained from the vicinity of the plant at Cato Ridge, South Africa, situated at the head of Mngeweni River. This tributary of the uMgeni River debouches to the sea just north of Durban, South Africa. The flow is highly seasonal and fed by large numbers of temporary streams in the lower valley. Permanent flow is due to a groundwater spring and the erratic contribution of two un-named tributaries. A marshland area exists at the confluence, where the permanent settlement of Fredville in the government-designated homeland of Kwazulu is situated (Figure 1).

Water samples were taken in 1-litre acid washed glass

Send reprint requests to P. Johnston at the above address

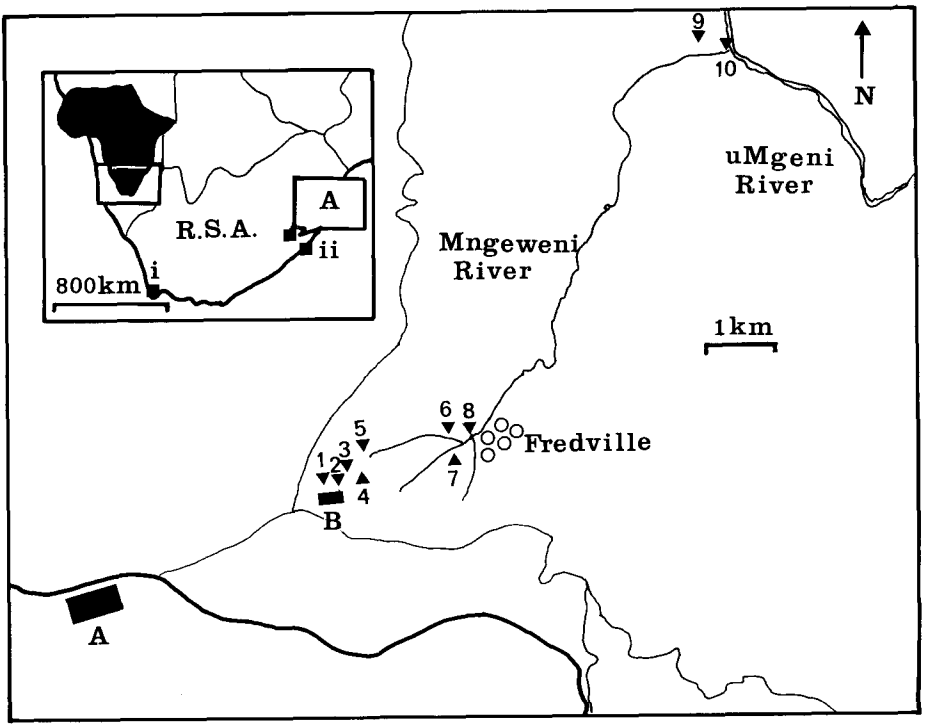

Figure 1. Study area and sample sites in the vicinity of the mercury recovery plant, Cato Ridge, Natal. The town of Cato Ridge (A) is shown on both the local map and the inset. Capetown (i) and Durban (ii) are shown in relation to S.Africa and Africa as a whole. The mercury recovery plant (B) is shown situated at the junction of two minor roads.

bottles rinsed with pesticide residue analysis grade hexane. Soil and sediment samples, taken using a polypropylene spoon, were stored frozen in nalgene bottles and transported frozen to the analyzing laboratory. After thawing, 4 grams of material were cold, wet-digested for twelve hours in concentrated analytical grade nitric acid and subsequently brought to boiling for one hour. Analysis was by cold vapour generation using stannous sulfate reduction according to the method of Hatch and Ott (1968), using a Thermoelectron 151 AAS. Aqueous samples were determined without digestion. Detection limits were determined at 1 ppb for aqueous solutions and 4 ppb for soils and sediments. Normal quality assurance procedures were carried out. Soil and sediment samples were analyzed for the <63 um particle size fraction percentage by wet sieving.

The sampling effort was principally directed towards evaluating contamination, its extent and probable source. Access to the site itself was not possible, while access to the lower Mngeweni river was prevented by difficult terrain. Soil samples were taken: 1) 50 m downslope of the evaporation ponds, an area clearly

receiving site runoff which was bare of vegetation; 2) adjacent to the site landfill area, close to the perimeter fence; 3) from the dried river bed below the plant; and 4) from the riverbank on the same side of the valley as the plant. Four samples were taken at site 5 which marks the point at which a groundwater spring beneath the plant establishes permanent flow in the river as follows: 5a) taken on the facility side of the river; 5b) from the opposite bank, approximately 1.5 m above the stream; and 5c) sediment from just below the source of the permanent river. A water sample was also taken at this point. A small earth dam had been constructed here and the river banks sampled appeared to be periodically inundated.

Further sediment samples were taken: 6) approximately 50 m upstream of the confluence of the tributaries; 7) for comparative purposes from the bed of the un-named tributary to the Mngeweni; 8) river sediment just above the settlement of Fredville; and 9) just above the confluence with the main river. Sample 10 was of alluvial material apparently carried down the Mngeweni river during periods of heavy flow and deposited at the confluence.

RESULTS AND DISCUSSION

Results of mercury determinations are given in Table 1, together with the <63 um fraction of the soils and sediments determined by wet sieving. These relate to the sites shown in Figure 1.

The results of analyses conducted upon the samples taken indicate extensive and serious contamination with mercury. Samples 1, 2 & 4, subject to runoff and adjacent to the landfill on the site, contained mercury levels in excess of the 10 ppm which, under the soil protection legislation in the Netherlands, would require remediation works (Van Gemert et al. 1988). Sample 3 contained 49.6 ppm of mercury which, under the same legislation, is close to the 50 ppm limit that would qualify the material as chemical waste. Identification of the recovery plant as a point source is consistent with the progressive reduction in mercury levels with increasing distance from site 3 to the permanent source of the river. Moreover, mercury levels in soil taken from the river bank opposite the plant (Sample 5b) are an order of magnitude lower than those found in soil from the same side as the plant (Sample 5a). The <63 um particle size fractions of each sample are similar.

An order of magnitude difference is found in sediment content of mercury between the un-named tributary which does not receive direct run-off from the plant, and the Mgeweni River, although some caution is necessary in making a comparison between these since the <63 um

Table 1. Results of mercury analyses and particle size fraction analyses for environmental samples taken in the vicinity of the mercury recovery plant. Location details are given in the text and in Figure 1.

SITE	SAMPLE	TYPE	<63 um Fraction (% Dry Wt.)	Hg (ppm Dry Wt.)
1	1	Soil	8.74	21.4
2	2	Soil	10.51	12.5
3	3	Sediment (Dry River Bed)	9.72	49.6
4	4	Soil (Dry riverbank)	9.56	11.4
5	5a	Sediment (Dry riverbank)	6.59	6.4
5	5b	Soil (Dry riverbank)	10.20	0.85
5	5c	Sediment (Mngeweni source)	2.06	1764.0
6	6	Sediment (River)	2.43	0.91
7	7	Sediment (Un-named tributary)	1.03	0.03
8	8	Sediment (Upstream, Fredville)	9.03	0.33
9	9	Sediment (uMgeni/Mngweni confl.)	2.72	0.03
10	10	Sediment (uMgeni/Mngweni confl.)	0.19	0.004
5	12	River water	-	N/D
8	13	River water	-	N/D

fraction of sample 7 is comparatively low at 1.03%. It seems likely that the extraordinarily high mercury content of sample 5c is due to mercury accumulated at the site from upstream areas and retained as a result of the earth dam found at this point. Although groundwater under the site may have been contaminated, mercury was not present at above detection limits in either of the river water samples taken.

The downstream samples taken near the uMgeni confluence show levels close to accepted background levels for many soils (DOE 1976). In this lower part of the river Mgeweni, (Sample 9) levels are similar to those in the sediment of the un-named tributary (Sample 7). However, both these samples had low fine particle fraction percentages. Hence, the apparent restriction of contamination to the upstream areas is probably misleading. Significant mercury contamination is likely to be associated with the fine fraction of sediments (Werther 1989) which will tend to be removed to the uMgeni river during the vigourous wet-season flows in the tributary Mngeweni. Increased rainfall would also help to mobilize mercury from the contaminated soils and the river-bed areas found in the vicinity of the plant. Under dry conditions, the major mobilization pathway from soils is likely to be by volatilization (Steinnes 1990; Malm et al. 1990).

Sediment transport from the Mgeweni River may have important implications related to the disposal of material removed from the new Inanda dam complex on

the uMgeni as a result of siltation. Any fishery activity taking place in the impounded waters will require careful monitoring to ensure protection of public health. Malm et al. (1990) noted that significant mercury contamination of biota exists 180 km downstream of the major areas of mercury use in the Madeira River, which they attributed to sediment transport and remobilization.

A hydrogeological survey is indicated in order to assess groundwater impact. A general remediation program is urgently required for the area and the exposure commitment of both the local and wider communities should be exhaustively evaluated for all environmental media. It is likely that the extensive contamination found will persist for many years. Dickson (1987) notes the continuing problem in the UK due to historical discharges. Mercury contamination does not respond well to retrospective action.

REFERENCES

Department of the Environment (1976) Environmental Mercury and Man. Pollution Paper No.10 Publ. HMSO (UK) 92pp

Dickson RR (1987) (Editor). Irish Sea Status Report of the Marine Pollution Monitoring Management Group. Ministry of Agriculture Fisheries and Food Aquatic Environment Monitoring Report No.17. MAFF Lowestoft 83pp.

Gemert WJ Th van, Quakernaat J, Veen HJ van (1988) Methods for the treatment of contaminated dredge spoil. In: Salomons W, Forstner U (eds) Environmental Management of Solid Wastes: Dredged Material and Mine Tailings. Springer-Verlag, New York, pp 44-64.

Hatch WR, Ott, WL (1968) Determination of sub-microgram quantities of mercury by atomic absorption spectrophotometry. Anal Chem 40: 2085-2087

Malm O, Pfeiffer W, Souza CMM, Reuther R (1990) Mercury pollution due to gold mining in the Madeira River Basin, Brazil. Ambio 19: 11-15

Steinnes E (1990) Mercury. In: Alloway BJ(ed) Heavy Metals in Soils. Publ. Blackie pp 222-236

Werther J (1989) Classification and dewatering of sludges. In: Salomons W, Forstner U (eds) Environmental Management of Solid Wastes: Dredged material and Mine Tailings. Publ. Springer-Verlag pp 65-79.

Received May 7, 1990; Accepted June 4, 1990.