22nd WEDC Conference: *Discussion paper* New Delhi, India, 1996

REACHING THE UNREACHED: CHALLENGES FOR THE 21ST CENTURY

Water systems and organohalide contaminants

N.P. Thacker, M.V. Vaidya, M. Sipani, P. Kaur and A. Rudra, India

IN RECENT YEARS, increasing environmental pollution has become a major contributory cause for deterioration in the quality of life. The increase in the consumption and production of synthetic chemicals viz. pesticides, fertilizers, industrial byproducts etc. has contaminated the water resources via waste water discharges, agriculture runoff, use in public health protection and pharmaceuticals etc.

The presence of such organic compounds have been reported in both ground and surface waters. Toxicological studies have linked some of these compounds to adverse human health effects. The data on health risk assessments by Morris and Barbara (1977) have correlated the risk of individual organochlorine compounds (OClPs) and carbon chlorine bonds. World Health Organisation (WHO, 1993) has regulated the guideline values (GV) for drinking water for 66 such compounds and of that more than 50 per cent are organohalides.

The present paper discusses the status of Indian water sources located in urban areas for OClPs and disinfection byproducts trihalomethanes (THMs).

Materials and methods

Sampling stations

Monitoring of OClPs and THMs were carried out in the water supplies of twelve major cities viz. Agra, Ahmedabad, Allahabad, Bombay, Calcutta, Delhi, Goa, Guna, Kanpur, Madras, Nagpur and Varanasi. 3 to 14 sites per city were selected which covered a total of 75 sampling stations. Individual species of THMs viz. chloroform, bromodichloromethane, dibromo-chloromethane and bromoform were monitored for instantaneous THMs (InstTHMs) and THMs formation potential (TFP) in pre- and post- chlorinated waters at the treatment plant and also at consumer ends.

The raw water sources of treatment plants were either river water, mixed river and lake water and underground water. At Agra, Allahabad, Calcutta, Delhi, Kanpur and Varanasi the raw water intakes were from the Yamuna, Ganga and Hooghly rivers. At Ahmedabad, Bombay, Goa, Guna, Madras and Nagpur, the raw water sources were generally mixed waters of rivers, lakes and underground waters. The finished waters of the treatment plants were maintaining a residual chlorine in the range of 2-3 mg/l just before discharging to consumer.

Sampling

Reported levels of organohalides in water resources are based on grab sampling. Samples for OClPs were collected in two-litre amber coloured precleaned glass bottles fitted with a screw cap lined with TFE. The samples were protected at 4°C until extraction. Samples for InstTHMs were collected in 125 ml capacity glass bottles with TFE septum seal and screw cap and preserved by adding ascorbic acid (20-30 mg/100 ml) at the time of sampling. No preservative had been added at the time of sampling in case of measuring TFP. Glass bottles of 125 ml capacity were completely filled with water sample to avoid air bubbles and capped tightly.

Invert sample bottle and lightly tap cap on a solid surface. The absence of entrapped air indicates a successful seal. If bubbles are present, open bottle, add a few more drops of sample, and reseal as above.

Blanks and samples, collected at a given site were stored together in a protected area known to be free from contamination. Samples were analyzed within 14 days of collection.

Methodology

The major steps which have been considered for the OClPs are: (1) extraction, (2) concentration, (3) separation, (4) detection and (5) quantification. To measure compounds at low levels, samples were extracted from the water matrix and concentrated. The components being analyzed were then separated. This procedure was followed by detection and quantification. For THMs, the sample extraction was carried out in a tightly closed vial and an aliquot of the extract was injected into gas chromatograph (GC) equipped with a electron capture detector (ECD). For TFP, water samples were buffered at pH 7, chlorinated with an excess of free chlorine, and stored at 25°C for 7 days to allow the reaction to approach completion. THMs concentration in the sample on 7th day was determined.

OClPs, InstTHMS and TFP were analysed in the water samples using earlier standardized methods (Standard Method for the Examination of Water and Wastewater, 18th edition, AWWA (1992); Thakkar N. and Muthal P.L., 1981; Thakkar N. *et. al.* 1990).

Results and discussion

Organochlorine pesticides

Intake of water treatment plants, final water, community open and tube wells, rivers and lakes located in the cities of Agra, Ahmedabad, Allahabad, Bombay, Calcutta, Delhi, Kanpur, Madras, Nagpur and Varanasi were surveyed. The pesticides covered in the study included HCH, heptachlor and heptachlor epoxide, Endosulfan I and II, p,p'- DDE, p,p' -DDD, o,p' and p,p' -DDT.

The OClPs levels reported for various sampling stations at Agra, Allahabad, Bombay, Calcutta, Delhi, Kanpur and Varanasi were based on monitoring during summer, rainy and winter reasons while at the other places it was based on a single survey. At Calcutta all the samples were collected under low tide conditions. (Charts detailing results of monitoring at these cities for Y-HCH and DDT (sum of p,p' -DDE, p,p'-DDD, o,p'-DDT) are available with the author).

OClPs were monitored at five sites at Agra including one of treatment plant. The average levels of Y-HCH exceeded the WHO GV of 2 ug/l. The levels of Y-HCH ranged from 0.04-17.61 ug/l. The average levels of total DDT were found below the GV of 2 ug/l. The levels of total DDT ranged from not detectable (ND) to 3 ug/l. Low ng/l of heptachlor and heptachlor epoxide were detected in very few cases.

OClPs were monitored at fourteen sites at Bombay including four treatment plants and six reservoirs located at different corners of the city. Y-HCH levels were below the GV and were reported in the range of ND-1.5 ug/l. Maximum level of total DDT 3.0 ug/l exceeding GV was reported only at one reservoir. Total DDT levels ranged from ND-3.0 ug/l. Endosulfan (sum of I and II) was detected only in few samples and the levels ranged from ND 1.8 ug/l.

OClPs were monitored at fifteen sites at Calcutta including five treatment plants. The average levels of Y-HCH were below the GV. The levels ranged from 0.001-0.41 ug/l. The average levels of total DDT were below the GV. Total DDT levels ranged from 0.002-0.56 ug/l. Low ng/l of heptachlor and heptachlor epoxide were detected in very few water samples. Endosulfan was not found in any of the samples. The average levels of OClPs at Dumurdaha (100km upstream of the river Hooghly) were generally lower than values of the other sampling sites.

OClPs were monitored at fourteen sites at Delhi including six treatment plants. The average levels of Y-HCH were below the GV. The level ranged from 0.001-0.74 ug/l. The average levels of total DDT in intake waters at four treatment plants were found marginally higher than (or equal) the GV. The average levels of total DDT in finished waters at all the treatment plants were below the GV. Low ng/l of heptachlor and heptachlor epoxide were detected in a few cases and levels were found marginally higher than GV of 0.1 ug/l in case of three samples of intake waters. The average levels of OClPs at Shyamli (70kms upstream of the river Yamuna) were lower than those at the other sampling sites.

OClPs were monitored at eleven sites at Kanpur including one treatment plant. The average levels of Y-HCH were below the GV. The levels ranged from 0.003-0.24 ug/l. The average levels of total DDT were below the GV. In intake waters the levels of DDT were found marginally higher than the GV. Heptachlor and heptachlor epoxide were detected only of the one raw water samples. Levels of all the OClPs tested at Bithur (30km upstream of river Ganga) were found lower than those at the other sampling sites.

OClPs were monitored at thirteen sites at Nagpur including two treatment plants. The average levels of Y-HCH were reported lower than the GV. The levels ranged from 0.030-1.78 ug/l. The levels of total DDT were below the GV, at all the sites and it ranged from ND-1/6 ug/l. Endosulfan (sum of I and II) was detected only in few samples and the levels ranged from ND-1.0 ug/l.

OClPs were monitored at five sites at Ahmedabad and at Madras for one treatment plant and private Sri-Ganesh water supply. OClPs were monitored at six sites at Allahabad and Varanasi including three of surface waters from each city i.e. the intake of treatment plants. Y-HCH levels were reported higher than the GV in the intake water of a treatment plant at Ahmedabad. The levels of DDT were higher than WHO GV in case of intake of the treatment plant and the Sri Ganesh water supply at Madras. Heptachlor and heptachlor epoxide were not found in any of the samples. Average levels of OClPs monitored at Allahabad and Varanasi were found ranging from ND to low ng/l.

Trihalomethanes

InstTHMS and TFP were determined in the water samples collected after pre- and post- chlorination at the treatment plants, reservoirs and distribution systems. Samples from the cities of Agra, Ahmedabad, Bombay, Calcutta, Delhi, Goa, Guna, Kanpur Madras and Nagpur were analyzed. The final treated water samples had a combined residual chlorine of 0.5-2.6 mg/l. The ambient temperature was 15-30°C during the collection of water samples. TFP were final measured in finished water (post chlorinated) and at distribution end. Water samples were collected from the distribution end located at an average distance of 3 kms from the treatment plant. All the treatment plants investigated comprised prechlorination, coagulation, sedimentation, filtration and postchlorination, excluding Nagpur where no prechlorination is practiced.

Conclusion

The reported data indicated the presence of OClPs, InstTHMs and TFP in the water sources. Treatment plants receiving the intake water from lakes were of high TFP values. The presence of these pollutants in water may be hazardous to human health. The available information on organohalides in water resources is of assistance in establishing preferred treatment technologies for drinking water supplies.

Acknowledgment

The authors are grateful to the Scientists, Instrumentation Division, National Environmental Engineering Research Institute, Nagpur, India for their kind cooperation during the sample analysis.

(Charts and illustrations available with the authors include: WHO Guidelines values for Organohalides in Drinking Water; General Analysis Scheme for Organohalides in Water, DDT Concentrations in Water Resources, etc.)