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AFFORDABLE WATER SUPPLY AND SANITATION

Industrial pollution of irrigation water

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ALL CONSIDERATION OF water supply and quality of water tend to concentrate on drinking water and potable water but in real life quality of water concerns even greater issues. Rivers, tanks and subsoil water are the principal sources of water supply, and rain water as well as melting snow augment them. It is obvious that mankind can not afford to pollute these water bodies. Yet, the fact remains that industrial growth, however essential, pollutes and virtually poisons these water bodies directly or indirectly. The present study, conducted over the last fifteen years, concerns itself chiefly with the deleterious effects of industrial pollution on water, particularly agricultural irrigation water.

The area chosen for study is recognised to be simultaneously one of the richest agricultural areas as well as industrial and mining areas in the country. Various kinds of factories, big and small, have grown up mostly in the last fifty years with sprawling agricultural fields all around. Rice, important oil seeds and vegetables are the chief agricultural products. The river Damodar is the principal source of water. It flows through the coal mine areas, crosses the huge factory areas producing steel, chemicals and a multitude of other items, supplies drinking water to the Durgapur township from an artificial reservoir created with the help of a huge barrage and last but not least provides irrigation water to millions of hectares of agricultural land. While some of the collieries and other industries discharge their effluents directly into the river, most of the industries release their effluents into rain water drains which ultimately end up in the river itself. Some of the industries dump their solid wastes such as slag over vast areas surrounding their sites. The environmental pollution is widespread but varies in intensity from season to season and from industry to industry. It affects human beings and domestic animals not only directly but also indirectly by entering the food chain through crop plants. The latter effect is often minute in the first instance and difficult to detect but is cumulative in nature and poses serious health hazards in the long run. The actual situation has been studied by using plant materials as indicators of water pollution.

Experimental procedure

A dependable bioassay method developed by Chou and his associates (1978) to assess the level of phytotoxicity of polluted water has been applied for the present work. Samples of polluted water have been collected from six different points on the river Damodar, the Barrage Reservoir and Tamla, a rain-drain turned into an industrial waste channel ending in the Damodar. A number of plant species are used at a time as test material for assessing phytotoxicity and the average value is taken as index of pollution level. A cardinal feature of the technique is that no previous knowledge of the pollutant is needed and therefore no preconceived notion can interfere. The method has been further extended and elaborated in the Department of Botany, Visva-Bharati by adding cytological observations (Ray and Banerjee, 1981) to those on radical growth. Cytological studies not only indicate the intensity of the effects of pollution but can even indicate the class of chemicals responsible for the damaging effect. The nature of intracellular damage serves as a good indicator in this respect (Ray 1987).

A detailed survey of the region carried on from 1980 onwards revealed the presence of a high level of water pollution in the study area. Accordingly, different plants were collected from various places; their roots, vegetative upper parts and seeds were collected and dried. Ash obtained from different samples were analysed using AASP method to determine the accumulation of different heavy metals in the plants.

In separate experiments the presence of naturally growing water hyacinth in the barrage reservoir was utilised to test their effect on the toxicity level of the water supplied for irrigation. Controlled experiments were conducted using polluted water of known toxicity for growing water hyacinth. The water was finally tested for toxicity, at specific intervals, to determine the maximum toxicity that water hyacinth can withstand and the time it takes to reduce toxicity of water.

Results

From studies conducted in 1980, it was found that Tamla water was highly phytotoxic. The toxicity gradually decreases from the confluence point further downstream. Laboratory experiments also showed that with dilution, phytotoxicity decreases for all water samples and for all test materials (Ray and Banerjee 1981). In the following three consecutive years seasonal variation in phytotoxicity were recorded for summer, monsoon and winter. Monthly rainfall was also noted. It was found that the water of Durgapur Barrage Reservoir and Tamla remained toxic throughout the year. It was also found that heavy rainfall in 1980 decreased phytotoxicity; further rainfall reduced toxicity still more in winter; but in 1981, summer and early monsoon witnessed rainfall below normal; further rainfall up till winter was also meagre. As a result, toxicity increased by the end of 1981. In 1982 drought conditions prevailed throughout the year and the level of phytotoxicity did not show significant seasonal variation either in the Barrage Reservoir or in Tamla water. The striking feature was that moderate rainfall in monsoon (1981) increased toxicity in the Barrage Reservoir water and to a still greater extent in Tamla water. This result can be explained if we consider the nature of the catchment area concerned (Ray and Banerjee 1984). When rain is insufficient (i.e. meagre to moderate) it may be enough only to wash down the solid pollutants into the water increasing toxicity, but not enough to dilute the pollutants sufficiently to remedy the situation. The same conditions are likely to prevail in respect of soluble gaseous pollutants also, suspended in the atmosphere.

Waste effluents from different industries, e.g. steel and tar, chemical and pharmaceuticals, distillery, power plant with coke oven etc., were found to be positively phytotoxic (Ray and Barman 1988). Further experiments were conducted to find out the effects of these waste waters on living plant cells. Allium sativum L. (Garlic) was used as test material. The results revealed that normal cell functions were severely disrupted and even the nucleus and chromosomes were affected. When treated with different factory effluents different effects were seen, indicating the presence of different categories of chemicals which affect the cell cycle differently (Ray and Barman 1988, Ray and Barman 1992, Ray and Saha 1992). It may be suggested from the results that these chemicals affect all living systems adversely.

In the period 1985 to 1988 different plant materials were ollected from cultivated areas irrigated with Tamla water. AASP analysis revealed the accumulation pattern of various heavy metals like Cd, Cu, Pb, Hg, Ni, Zn and Mn in different edible parts of onion, mustard, radish, Indian spinach, coriander, potatoes, bottle gourd and also some weeds like Amaranthus spinosus L. Parthenium hysterophorus L and Croton sperciflorum Morr. Among the edible plants it was found that copper accumulated most in whole plants of coriander (55 ppm) and mustard (50 ppm). In other plants accumulation of copper varies from 20 ppm to 50 ppm. Highest accumulation of cadmium was found in whole plants of the weed Parthenium hysterophorus which was 65 ppm. Accumulation of cadmium in vegetables varied from 20 ppm to 50 ppm; Zinc from 65 ppm to 235 ppm; lead from 20 ppm to 240 ppm (Ray 1989). Another set of experiment revealed that Cd, Pb, Cu, Zn, Ni, Co, Mn etc. accumulated in high quantities in different parts of rice, pulses and oil-seeds and vegetables from root to grains (Ray, Barman and Khan 1989). In rice, copper accumulation in roots varied from 40 ppm to 75 ppm, in the straw from 20-25 ppm, in the grain from 20-80 ppm; cadmium accumulation in roots and straw was 20 ppm and in grains 20-30 ppm. It was found that the highest quantity of Hg accumulated in the leaves; in radish it was 1430 ppb, in Indian spinach 1290 ppb, in onion leaves 1260 ppb, coriander 440 ppb, in mustard 270 ppb in vegetative parts and 330 ppb in the seeds.

The plant materials collected in the next year showed remarkably lower accumulation of mercury; in radish for instance it was 86 ppb only. Most probably this was due to known implementation of pollution control measures at the time laying down standards for maximum permissible discharge of mercury from chlor-alkali industries which are the main sources of mercury pollution.

Now it is established beyond doubt through scientific research that mercury in any form can be converted to easily absorbable methyl mercury in water environment by bacterial action.

It is the accumulation of methyl mercury in the human body that causes the deadly Minamata disease. It is well known that consumption of cadmium-containing cereals over long periods cause a fatal disease called “Itai Itai” (Yamagata and Shigematsu 1970). Obviously, cadmium consumed through sources other than cereals will also produce the devastating effects. Lead poisoning is also a direct effect of consumption of vegetables and plant products in which lead has accumulated.

Similarly Cu, Co, Zn, Ni, Mn and many other metals passing from industrial waste into water and soil, attain higher concentrations and accumulate in dangerous quantities in different plant parts and finally pose serious health hazards to human beings and domestic animals through biomagnification. The quantity of the different trace metals was found to be often considerably higher in the plants than in the polluted soil and water (Ray 1990). In 1986 three varieties of rice were grown in the study area and also in unpolluted control plots. The growth and yield parameters of the plants in the study area were severely affected. Seeds were collected from the affected plants and sown again in the same polluted area. The second generation of plants so obtained were almost normal and some growth parameters even exceeded the normal limits (Ray, Barman and Khan 1989). This clearly established that rice plants adapt very fast to polluted environment in spite of the accumulation of dangerous elements in the plant body. This only highlights the danger of polluting irrigation water, for human beings do not posses even a small part of the tolerance the plants have.

Yet another set of experiments in the field and the laboratory clearly established the ability of water hyacinth to tolerate pollution and absorb pollutants quickly and to a remarkable extent (Ray, Banerjee and Burman 1986; Ray and Saha 1989; Gopal and Sharma 1980). These properties of water hyacinth can be easily used for reducing toxicity of diluted effluents and removal of heavy metals. The water hyacinth has to be harvested every fortnight and metals recovered through proper technology to protect irrigation water and agricultural fields from cumulative poisoning.

Thus it may be concluded that pollution of irrigation water is a matter of serious concern as important as the pollution of drinking water and needs to be tackled from every possible angle, simultaneously using industrial technology, biotechnology, legal measures and environmental awareness education.

References

1. Barman, S and Lal, M.M. 'Accumulation of heavy metals (Zn, Cu, Cd, Pb) in soil and cultivated vegetables and weeds grown in industrially polluted fields'. J.Environ. Bio. 15(2), 115-123 (1994).
2. Chou, C.H., Chiang, Y.C. and Kao, C.I. 'Impact of water pollution on crop growth in Taiwan. II phytotoxic nature of six river waters and twenty seven industrial waters in Kaohsiung area.' Taiwan Bot Bull. Academia Sinica 19: 107-121 (1978).
3. Gopal, B. and Sharma, K.P. 'Water-hyacinth'. Hindasia Publ. India, (1981).
4. Ray, M. and Banerjee, S. 'Detection of phytotoxicity in irrigation water passing through the industrial belt of West Bengal'. Proceedings of the VIth. International Conference of Women Engineers and Scientists, Bombay, pp 59-64, (1981).
5. Ray, M and Banerjee, S. 'Phytotoxicity as a measure of quantitative and qualitative variations in water pollution'. Journal of IPHE, India, vol. (1) pp 19-26, (1984).
6. Ray, M. 'Plants as indicators of environmental pollution'. XIV International Botanical Congress, Berlin (W), Abstract No. 6-147-5, p 422, (1987).
7. Ray, M and Barman, S. 'Effects of industrial waste water on root meristem cells of Allium sativum L'. Phytomorphology, vol. 37(4), pp 359-364, (1987).
8. Ray, M and Barman, S. 'Physiological responses of crop plants to waste effluents from (i) steel and tar, (ii) cycle and (iii) distillery industries'. Ind. Biol., vol 20(1), pp 16-18, (1988).
9. Ray, M. Barman, S and Khan, S. 'Heavy metal accumulation in rice plants: adaptation to environmental stress and consequent public health risks'. Plants and Pollutants in developed and developing Coun University Press, Bornova-IZMIR, (1989).
10. Ray, M. and Saha, R. 'Effects of industrial waste effluents on water hyacinth and role of water hyacinth in reducing phytotoxicity'. Journal of IPHE, India, vol 1989 No. 2, pp 36-42, (1989).
11. Ray, M. 'Accumulation of heavy metals in plants grown in industrial areas'. Indian Biologist, vol XXII, No. 2, pp 33-38, ISSN 0302-7554, (1990).
12. Ray, M. 'Accumulation of mercury in plants: sites, quantities and health hazards'. Recent researches in Ecology, Environment and pollution, vol 4: 213-224, Eds. Malabika Ray and Sudhendu Mondal, Today & Tomorrow's Printers and Publishers, New Delhi-5, India, (1990).
13. Ray, M and Barman, S. 'Effects of industrial effluents on root meristem cells of Allium sativum L. : (i) pharmaceutical industry, (ii) power plant with coke oven'. Perspectives in Cytology and Genetics, Ed. G.K.Manna & S.C.Roy, vol VII, pp 1167-1175, (1992).
14. Ray, M and Saha, R. 'Cytological effects of industrial effluents on root meristem cells of Allium sativum L. : carbon black and chemical factory effluents'. Perspectives in Cytology and Genetics, Ed. G.K.Manna and S.C.Roy, vol VII pp 655-663, (1992).
15. Young, J.L and Crossman(Jr), R.A. 'Eutrophication control by plant harvesting'. J.Water Poll, Cont. Fed. 42: 173-183, (1970).