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RESEARCHES IN WATER POLLUTION: A REVIEW

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ABSTRACT

More than 70% of the fresh water in liquid form of our country is converted into being unfit for consumption. Not only India, but other countries are also suffering from the same problem. This has been explained clearly by the help of considerable number of references in this paper. Various sources of pollution such as sewage discharge, industrial effluents and agricultural runoff and their potential has been studied in mass. Various prescribed standards for different category of inland water have been explained. The paper also consists of the potential and extent of various components which pollute the water. Finally, effect of water pollution has been shown in nutshell.

Key words: Pesticides, Pharmaceuticals, Nutrient, Turbidity, Microbial pollution, Heavy metals, Runoff

INTRODUCTION

Our survival on Earth depends on three basic resources – water, air and soil, nature's three valuable gifts to mankind. Among which water is the most important component as it forms the basic medium for origin of life. Demand of water rose six-fold between 1900 and 1995, more than double the rate of population growth (Postel, 1997). The first serious effort to take note of the environmental issue at the global level was at U.N. Conference held at Stockholm in June 1972, which was projected towards human environment. Thereafter the concepts like

environment, sustainability and carrying capacity of Earth have become the central theme of policy making round the globe (Gupta, 2001).

Various resources of water at global level have been studied and explained by Gleick (1993). In his studies Falkenmark (1993) has pointed out the importance of pure water and its importance in the near future. A multidimensional aspect of water has been studied by Edwards et al. (1989). Chemical and biological aspects and their interactions in polluted water have been discussed in the work of Dugan (1972). Urban civilization requires more water as compared to the rural and also the quality of discharged water of the urban area is chemically more toxic (Bandy, 1984).

Study of chemical composition of waste water in Amritsar city was conducted by Panesar et al. (1985) in which they have reported about the suitability of the water for various uses.. Pollution in Chambal river at Kota was studied by Olaniya et al. (1976) and the water was reported to be moderately polluted at most of the study sites. A comparative study of chemical characters of surface water in river Godavari, Krishna and Tungbhadra was conducted by Mitra (1982). Similar comparative study was conducted between rivers Ganga, Yamuna and Kali by Bhargava (1977) also. Chemistry of river Godavari was studies in Rajamundhary by Ganpati and Chacko (1951). Management of fresh water pond in Varanasi was conducted by Mishra (1993). Pollution in Gandak river at Samastipur was studied by Hakim (1984). In most of the studies it has been a parallel reporting that the water quality is deteriorating day by day. The academicians have warned to check the pollution of water.

STATUS OF GROUNDWATER

Presently the annual requirement of water globally is around 6000 to 7000 Km^3. The groundwater reserve globally is about 70, 000, 00 Km^3. This surplus amount of water is brought in to the ground annually by the process of precipitation and percolation. For the last few years, due to over withdrawal and limited rainfall, the low replenishment has lead to lowering of the water table. Concretisation of the cities is also an important factor. Therefore, shortage of water is occurring alarmingly depending on regional water balance, controlled largely by climate, altitude, soil composition, vegetation cover, precipitation and percolation. A conjunctive use of

surface and groundwater in a judicious manner after due consideration of factors influencing water must be planned.

Thus, it becomes the need to use the water in much planned way and also, recycling of the water must also be considered. It is easy to explore the surface water through aerial photography and remote sensing; But in the case of groundwater, complete evaluation of ground surface is needed. The role of surface and subsurface geological and geophysical methods in groundwater exploration and development is now well established and globally accepted.

RIVER POLLUTION IN INDIA

Water pollution in India has now reached a critical point. Almost every river system in India is now polluted to a considerable extent. As assessed by the scientists of the National Environmental Engineering Research Institute (NEERI) Nagpur, nearly 70% of water in India is polluted (Martin, 1998). Pollution in river Ganga has been studied by a considerable number of scientists. Physico-chemical characterisation of the same was studied in Mirzapur by Shukla (1989) and in Varanasi by Shukla et al. (1989). Both the works culminate into a common conclusion that the physico-chemical properties of Ganga water has degraded continuously and still it is following the same suit. Bacteriological pollution was studied in river Ganga by Shukla et al. (1992) and in river Varuna by Shukla et al. (1988). The reports favour the presence of a large number of pathogenic and non-pathogenic microorganisms in much beyond their excess limit. Quality of sewage water entering the river Yamuna was studied by Sharma et al. (1981). Quality of water of river Yamuna in Agra was studied by Sangu et al. (1984) and at Okhla by Mohan et al. (1965). Bacterial study in Yamuna at Delhi was studied by Kaushik and Prasad (1964). Biological properties of river Yamuna is much more poor in most of cities as compared to river Ganga. Study of river Gomati in India with respect to blue-green algae was conducted by Prasad and Saxena (1980). Similar studies in river Mahanadi was conducted in Orissa (Patra et al., 1984). Pollution in river Bhadra in Mysore was studied by David (1956). Study of pollution in selected rivers of Andhra Pradesh was conducted by Venkateshwarlu (1986). Pollution in Tungbhadra reservoir was studied by Rao and Govind (1964). Physico-chemical properties of water of Hoogly estuary at various points was conducted by Basu (1966). Agrawal and Srivastava (1984) conducted pollution studies in Ganga and Yamuna at Allahabad.

Physico-chemical characters of Sone river was studied by Grover et al. (1988). Study of river Kali in Aligarh with respect to biotic community was studied by Chatterjee et al. (1981). Similar study in river Alaknanda was conducted by Badola and Singh (1981). Similarly, Neyyar river was studied by Nair et al. (1989), and Kanhan river in Nagpur by Deshmukh et al. (1984). In the above studies none of the rivers were reported to be pollution free. This is very disgusting for country like India was the rivers are treated as Goddess.

INTERNATIONAL STUDIES IN RIVER POLLUTION

Parallel studies were conducted at international level also. Watelet and Johnson (1999) studied the quality of river Raisin in Canada and Reichert (2001) in river Glatt in Switzerland. Chemistry of river Nile with respect to macrophytes was done by Obeid and Chadwick (1964). Chemistry of river Amazon was studied by Gibbs (1972) and with focus at its microbiological aspect by Rai and Hill (1984). Nutritional character of river Rhone in France was studied by Fauvet et al. (2001) and in Welsh rivers in U.K. by Brooker (1984). Nutrient analysis in Mississippi river was done by Bollinger et al. (1999). Limnological study in the same river was conducted by Galtsoff (1924) and in Missouri river by Berner (1951). Study of nutrient pollution and eutrophication in Costal river of Israel was done by Herut et al. (2000). Physico-chemical study of lake Mellwaine in Rhodesia was done by Marshall and Falconer (1973). General stream pollution was studied by Ellis (1937).

Multidisciplinary study of river Aliakman in Greece was conducted by Lazaridou et al. (1999). Chemistry of river Odzi in Zimbabwe was studied by Jannalagadda and Mhere (2001). Similar study in river Niger by Imevbore (1978) was also conducted. Heavy metal analysis in some estuary of France was conducted by Cossa and Noel (1987). Growth of macrophytes in some lakes of Florida was studied by Center and Spencer (1981). Similar study in Detroit river of Michigan was studied by Manny et al. (1988), heavy metal pollution in the same river was studied by Manny et al. (1991) and its impact on biotic component of the river was conducted by Manny and Kenaga (1991). The literature shows that the problem of water pollution is not restricted only to India but the complete globe is struggling against it.

SOURCES OF POLLUTION

Generally, the pollutants come from three prominent sources-

(i) sewage discharged into the river,

(ii) industrial effluents discharged into the river without any pretreatment and

(iii) surface run off from agricultural land, where chemical fertilizers, pesticides, insecticides and manures are used.

This makes the river water unsafe for drinking and bathing. About 1500 substances have been listed as pollutants in freshwater ecosystems and a generalised list of pollutants includes acids and alkalies, anions (e.g. sulphide, sulphite, cyanide), detergents, domestic sewage and farm manure, food processing water, gases chlorine, ammonia), heat, metals (cadmium, zinc, lead), nutrients (phosphates, nitrates), oil and oil dispersants, organic toxic wastes (formaldehydes, phenols) pathogens, pesticides, polychlorinated biphenyls and radionuclides, in addition to oxidizable materials, domestic sewage contains detergents, nutrients, metals, pathogens and a variety of other compounds (Tripathi et al., 1990).

Now a day a large number of factors are being used for the study of pollution. A modification in biology of polluted water was explained by Chen and Twillery (1999). Silicon and nitrate in fresh water was studied by House et al. (2001). Biological character with respect to physico-chemical properly in ponds was studied by Dwivedi (2000).

Effluents of large and small scale industries, agricultural runoff and city sewage have been marked as sources of pollution during various researches. Effect of sewage on the quality of river Ganga in Kanpur was studied by Ray and David (1966). The same study was repeated in Patna by Singh and Bhowmik in 1985. Heavy metals in sewage sludge have been found by Oake (1985). Chemistry of urban runoff water had been studied by Lee and Bang (2000). Similar study in the sewage of Ahmedabad was conducted by Kothandaraman et al. (1963). Effect of sewage disposal in the chemistry of water bodies had been studied by Cooke (1994). Biology of sewage was studied by Sutton and Ornes (1977). Pollution aspect of sewage overflow was studied by Balmforth (1990). Change in chemistry of Chambal river due to sewage was studied by Agarwal (1983). Chemistry of runoff water containing birds and animal waste was studied by Sauer et al. (1999).

Crude agricultural practice is considered as an important source of water pollution. Pesticides in river water have been detected by Blanchard and Lerch (2000). Herbicides used in agriculture were also detected in river water (Galiulin et al., 2001). The above has shown positive test for the presence of large number of pesticides and heavy metals in grains, fruits, vegetables and milk. These components would have reached to such target directly or indirectly and accumulated due to biomagnificaiton. Remains of funeral pyre (burning of dead bodies) increases organic matter in river (Tripathi et al., 1984).

Industries generate a significant quantity of wastewater which ultimately finds its way to stream or rivers. Industrial discharges containing toxic and hazardous substances contribute to the severe kind of pollution in the aquatic systems. Industrial development is largely because of the production of chemicals resulting in the generation of toxic and hazardous substances which have been continuously on the increase during the last few decades (Table 1).

Table 1: Toxic chemical production in India (During 1960 to 1987)

Industries	**Pollutants Released (Thousand tonnes)**			
	1960	**1970**	**1980**	**1986-87**
Pesticides	1.46	3.00	40.68	56.20
Dykes & Pigments	1.15	13.55	30.85	-
Organic Chemicals Petrochemicals	580	17,100	24,100	42,500
Fertilizers	153	1059	3005	7000
Steel (Ingots)	1500	3400	8000	9000
Non-ferrous metals	8.5	34.6	82.9	123.4
Caustic soda	101	304	457	764
Pharmaceuticals	1.23	1.79	5.07	-

Source : GOI Publication, India, 1988-89.

Mushrooming of large and small scale industries have generated a large amount of effluents. Industrial effluents cause serious menace to aquatic environment by entering in the food chain. Dairy effluent is rich in microbial population (Mohanta, 1984). Plant distribution as affected by paper mill effluent was studied by Balchand and Nambisan (1986). Kudesia and Verma (1986) conducted the study of chemistry of river Kali affected by sugarcane, chemical,

distillery and rubber industries. Water pollution in river Cauvery in response to effluent of chemical factory was conducted by Ganpati and Alikunhi (1950). Industrial effluents affect BOD and COD, this was observed by Gajghate and Reddy (1989). Chemistry of sugar mill effluent was studied by Verma et al. (1978). Pharmaceutical industrial waste affecting the microbial population in water was highlighted by Ajmal (1980). The same affecting behaviour of macrophytes in Israel was studied by Agami et al. (1976). Industrial units discharging heavy metals were studied by Azad et al. (1982). Even trace elements were found in river water by Paul and Pillai (1983). Bhuyan (1970) conducted the analysis of water of some ancient tanks in Sibsapur.

The above studies show the vast range of water polluting sources. It is our conclusion that all the efforts of studies of water pollution is of no use if the suggested remedial measures are not followed or adopted. As a matter of fact lots of money is spend through the projects for finding the solutions of certain problem. It requires tremendous man power, precious time and also the money, just to find some solution of the problem; but in most of the cases, the findings suggested by the great brains have been ignored by the power.

WATER QUALITY STANDARDS

Standards of different category of water have been prescribed by different health agencies (Lester, 1969). Some of such type of agencies are U.S. Public Health Service Drinking Water Standards (USPHS) (1962), Indian Council of Medical Research (ICMR) (1962), World Health Organisation (1992) etc. Standards are essential because the quality of water directly affects the human health (Umar, 2000). Water quality standards prescribed for inland water by different agencies has been given in table 2.

Table 2: Water Quality Standards for Inland Waters

Parameter	USPHS	BIS	WHO	ICMR
Temperature ^{0}C	-	40.0	-	-
EC Sm^{-1}	0.03	0.075	-	-
pH	6.0-8.5	6.5-8.5	7.0-8.5	6.5-9.2
DO mg L^{-1}	>4.0	>5.0	-	-
BOD mg L^{-1}	-	<3.0	-	-

COD mg L^{-1}	-	<20.0	-	-
Chloride mg L^{-1}	250	250	200	250
Alkalinity mg L^{-1} $CaCo_3$	-	-	-	81-120
Nitrate mg L^{-1}	10.0	50.0	45.0	20.0
Phosphate mg L^{-1}	0.1	-	-	-
Sulphate mg L^{-1}	250	150	200	200
Total hardness mg L^{-1} $CaCo_3$	500	300	100	300
Total solids mg L^{-1}	500	-	500	-
Calcium mg L^{-1}	100	75	75	75
Magnesium mg L^{-1}	-	30	-	50
Potassium mg L^{-1}	-	-	-	20
Sodium mg L^{-1}	-	-	50	-

- Not available

Tripathi (1982) studied biological indicators for water quality in river Ganga. Similar studies were conducted at Nagarjun Sagar Reservoir by Pathak (1979). Bacterial parameters have been used to study the quality of swimming pools of Geldreich (1970). Brown (1971) also advocated the use of biological indicator for water quality. The qualities of effluents discharged from different units vary and their standards also varies according to the nation (Ragas and Lenven, 1999).

Allocation of the most polluted point in a river when different sources meet transversely was done by Li and Morioka (1999). Developments in methods of analysis of waste water were also done by Bansho and Miyazaki (1983).

COMPONENTS OF POLLUTED WATER

Nutrient Content

Nitrate and phosphate which is most often present in the runoff water of rural as well as urban area act as nutrient in the waterbodies. Concentration of the same in water, sediment and macrophytes was conducted by Tripathi et al. (1998). Denitrifying bacteria also play an important role in nitrogen concentration of a medium (Saunders and Kalff, 2001). Biological nutrification and denitrification was studied by Montigomery et al. (1991). Detailed investigation

of nitrogen level in lotic ecosystem was done by Mitchell et al. (2001). Blue baby is one of the prominent symptoms of nitrate pollution in ground water which is considered potent enough to kill the coming generation.

Phosphorus in aquatic system is recycled by absorption by plants (Stratful et al., 1999). Phosphorus in aquatic medium also plays an important role in aquatic plants. Nitrogen and phosphorus accumulation in water hyacinths was reported by Boyd (1976).

Temperature

Some industries discharge hot water directly in the water bodies which disturbs the aquatic ecosystem as a result of thermal pollution. The important industries which cause thermal pollution are nuclear powers, power generators etc. where water is used as coolant, but nearly all the industries contribute for the above, though they vary in their extent.

Modification in surrounding temperature affects the biodiversity of any ecosystem. Bacterial population reduction in response to thermal pollution was studied by Zeikus and Brock (1972). Temperature also affects electrical conductance of water (Talbot et al., 1990) which may be a prominent factor of biodiversity modification. Oxygen content in water is also affected by temperature (Steele, 1989), increasing temperature renders the oxygen to flee from the medium. Rate of biodegradation of organic compounds increases by increase in temperature, this further adds to the reduction of DO and nutrient accumulation. Distribution pattern of plants with respect to temperature and light was studied by Dale (1986). Thermal pollution alters the aquatic ecosystem disturbing the natural food web resulting into many abnormalities.

DO, BOD and COD

The total oxygen content in dissolved form in a litre of water is called as dissolved oxygen. BOD of a water sample is the amount of oxygen spent for biochemical processes during 5 days at 20^0C. COD is the quantity of oxygen required for complete oxidation of all reducing substances of organic as well as inorganic origin present in the water. Relationship between BOD and COD in river Ganga has been studied by Tiwari et al. (1986). BOD is directly and indirectly affected by the presence of toxic metals (Mittak and Ratra, 2000). DO affect the sewage treatment (Vollertsen et al., 1999). DO of water is also affected by turbidity which restricts the solar radiations. Roots of aquatic plants also increase DO by performing

photosynthesis as most of them contain chloroplast. Oxygen budget of any aquatic system is balanced naturally in unmanned condition.

Turbidity

Turbidity of water is affected by SPM (Suspended Particulate Matters) present in the water. In view of its importance Mitchell and Furnas (2001) have designed river Logger, an instrument to monitor the aquatic SPM.

Trace elements were reported in the SPM of many rivers, including Yarra river in Australia (Sinclair et al., 1989). SPM also affects the biotic community as studied by Cairns (1968). Chemistry of water affects the chemistry of SPM and sediments, as reported by Lau et al. (1989) and Leonard et al. (2001). Turbidity not only affect the water chemically but it reduces the photosynthetic activity of the water body retarding the DO which causes suffocation to the aquatic life.

pH

pH is the negative log of H^+ concentration present in a sample. A specific pH is essential for the normal survival of any organism. pH affects the enzymatic activity, thus indirectly affect the elemental mobilisation. pH also affects the distribution of plants. The study of changing phytoplanktonic composition with respect to lowering of pH was conducted by Findlay (1984) in lake 223 of Canada.

Organic Matter

Organic as well as inorganic carbon affects the eutrophication (Goldman, 1972) which ultimately affects the chemistry of river (Crowder, 1991). Pollution caused by spillage was studied by Sharma (1999). Toxic organic contaminants of agricultural origin in water stream were also reported by Thanas et al. (2001). Organic pesticides in a river of Buenos Aires and Argentina have been studied by Rovedatti et al. (2001). Presence of particular organic compounds is responsible for specific odour (Ma et al., 2001). Some hydrophytes growing in carbon rich medium have capacity to absorb inorganic carbon for photosynthesis (Raven, 1970). Seasonal variation in organic content is found in the water bodies (Pocklington and Tan, 1987). Organic phosphates have been shown to be absorbed by some selected microorganisms

(Longowaska, 1982). Dead plant parts fall in water and increase the organic content as reported by Villar et al. (2001).

Heavy Metals

Heavy metals are present in a variety of industrial effluents. They are absorbed by hydrophytes (Villar et al., 1999). These metals also precipitate in the sediments (Gonzalez et al., 2000). Cr absorption by duckweed was reported by Staves and Kanaus (1985). Cr and Mn uptake by *Hydrilla* was studied by Sinha et al. (1993), the same by mosses was studied by Say and Witton (1983). Hg in hydrophytes and herbivorus fishes was reported by Risgard and Hansen (1990). Metal content in various strata of rivers was studied by Pacakova et al. (2000). Due to nutrient absorption property of some plants they were advocated as biological filters (Reddy and De Busk, 1987).

Accumulation of Cu, Pb, Mn and Fe by *Hydrodictyon*, an alga was reported by Rai and Chandra (1992). Cd and Pb accumulation by rooted aquatic plants have been shown by Mayes et al. (1977). Hg, Cd, Pb and Tl has been reported to be present in a nutrient rich lake (Mathis and Kavern, 1975). Bioaccumulation of Hg and Cr has been studied by Jana (1988). Pb and Zn removal by *Azolla* and *Lemna* has been reported by Jain et al. (1990). Zn uptake by water hyacinth was studied by Abaychi (1987). Zn, Cd and Pb uptake by *Lemna* was reported by Guilizzoni (1991). Metals were also reported in composted municipal waste by Ciba et al. (1999). Lichen *Peltigera* has been reported to absorb Cd (Beckett and Brown, 1984). Cr accumulation in *Ceratophyllum* was reported by Garg and Chandra (1990). Cd accumulations in Eichhornia have been reported (Maine and Duarte, 2001). Ag was reported in the sediments of rivers and estuaries by Gobeil (1999). Chemical composition of waste water in Amritsar city was studied by Singh et al. (1985). Behaviour of Lanthanide-920-dye complex in water was studied by Srivastava (1996). Response of metal dye complexes were studied in waste water by Tiwari (1993). The latest studies have reported many type of cancers prominently gall bladder cancer due to accumulation of heavy metals such as cadmium, copper and nickel. These reach to the target site through the food chain.

Microbial Pollution

Microorganisms have been reported to be present in sediments of ocean by Volterra et al. (1985). Some microorganisms are helpful in removal of nutrients from the water bodies (Tam and Wang, 1989). Underground water have also been reported to contain bacteria (Anderson and Stentrom, 1987). Relationship between coliform bacteria and organic pollution level had been studied by Hiraishi et al. (1987). Coliform number has been studied in Jordan river by Hades et al. (2000). The reaching of microbes even to the underground water is an alarm because we have more or less spoiled most of the surface water but ground water which is a heritage should be protected.

WATER POLLUTION AND ITS EFFECTS

Chemistry of water, controls distribution of the fishes in waterbodies as studied by Shieh et al. (1999). Multidimensional effect of environmental pollution was studied by Pritchard (1985). Impact of bathing water quality on health was studied by Stevenson (1953). Effect of pollution on *Euglena* was studied by Manawar (1972). Effect of heavy metals on submerged macrophytes was studied by Guilizzoni (1991), similarly effect of acidification on the aquatic fauna was studied by Pamela and Stokes (1986).

Heavy metals settling in sediments of contaminated water was reported by Vandenberg et al. (1999). Pollutants concentrating in the sediments have been highlighted by Smith (2001). Various reports show that 80% of mortality is due to water pollution. Presence of heavy metals in grains, vegetables, fruit and milk has shown that nothing has remained pure in this universe. Heavy metals which are causative of large number of un-understood diseases should be treated carefully.

CONCLUSION

In light of the above study we come to the conclusion that the level of water pollution have reached to the alarming stage. The quality of water in most part of the world has degraded, though the situation in India is more severe. Indian philosophers believe that "thought of a person depends on the type of food and water to which he is fed". The above contention is well scientific, because as we ingest contaminated food and water the normal physiology is disturbed. Our body consists of about more than 10000 hormones and enzymes which are very specific in

their requirement and kinetics. If any undesired material enters into our body it affects the mechanism of the hormone or enzyme activity in question.

We are unaware of the fact that we are consuming considerable amount of DDT, BHC, Aldrin and many other pesticides in addition to a variety of heavy metals alongwith our diet. The entry of these xenobiotics should be avoided. We must not use pre-seasonal fruits and vegetables as they require large amount of chemical fertilizers and pesticides to develop in the adverse situations.

We have conquered the nature to pollute it but still we have failed to understand the nature policy even less than 10%. Daily thousands of casualties are reported, most of them are told to be due to heart attack. It is a big question before the cardiologists that is only heart, the most sensitive organ in our body? Because accumulation of the xenobiotic compounds has been reported in different specific target organs which are important cause of deaths now-a-days but its actual cycle is unexplored. No compound in nature is medicine or poison, it is only the those to which the subject is exposed. Thus, it becomes our responsibility to check the accumulation of higher dose of any compound in the ecosystem.

It is demand of the time to move towards sustainable development. We should think of even those generations which have still to appear on this earth. We must notice that ours is not the last generation to flourish on this earth, remember, they will be our sons or grand-sons.

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