International Journal of LatestResearch in Engineering and Management" (IJLREM)
ISSN: 2456-0766
www.ijlrem.org Volume 3 Issue 7 ǁ July 2019 ǁ PP 06-11

Diffuse Chemical Pollution in Vindhya Pradesh

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Review of Literature

Water is vital to the existence of all living organisms, but this valued resource is increasingly being threatened as human populations grow and demand more water of high quality for domestic purposes and economic activities. Water abstraction for domestic use, agricultural production, mining, industrial production, power generation, and forestry practices can lead to deterioration in water quality and quantity that impact not only the aquatic ecosystem (ie. the assemblage of organisms living and interacting together within an aquatic environment), but also the availability of safe water for human consumption. It is now generally accepted that aquatic environments cannot be perceived simply as holding tanks that supply water for human activities. Rather, these environments are complex matrices that require careful use to ensure sustainable ecosystem functioning well into the future. Moreover, the management of aquatic environments requires an understanding of the important linkages between ecosystem properties and the way in which human activities can alter the interplay between the physical, chemical and biological processes that drive ecosystem functioning.

Providing safe and secure water to people around the world, and promoting sustainable use of water resources are fundamental objectives of the Millennium Development Goals. The international community has recognized the important links between ecosystem and human health and well-being, particularly as human populations expand and place ever greater pressures on natural environments. However, the ability to properly track progress toward minimizing impacts on natural environments and improving access of humans to safe water depends on the availability of data that document trends in both space and time. As such, ongoing monitoring of both water quality and quantity in surface and ground water resources is a necessary activity at all governing levels: local, national, and international.

Water quality and quantity are intimately linked although not often measured simultaneously. Water quantity is often measured by means of remote hydrological monitoring stations which record water level, discharge, and velocity. Monitoring of water quantity can be undertaken, to a certain degree, with a minimal amount of human intervention, once a monitoring station has been set up. In contrast, water quality is usually determined by analysing samples of water collected by teams of personnel visiting monitoring stations at regular intervals. The costs associated with monitoring the many parameters that influence water quality, when compared to those associated with monitoring only a few water quantity variables, usually means that water quality monitoring is not undertaken as frequently as water quantity monitoring. However, the results of water quality monitoring are vital to being able to track both spatial and temporal trends in surface and ground waters.

At the 1992 Rio Earth Summit, the main expressed problems affecting water quality and aquatic ecosystems were untreated domestic sewage, uncontrolled industrial discharges, deforestation and poor agricultural practices that result in soil erosion and leaching of nutrients and pesticides. Public awareness regarding the protection of the freshwater resources as well as monitoring of the ecological and human health effects were also considered inadequate. Agenda 21, the plan of work adopted to conserve and protect the environment, called for the adoption of a catchment management approach and the “polluter pays” principle as well as for immediate action on ecosystem restoration and monitoring, groundwater protection, treatment facilities for domestic sewage and industrial effluents and rational use of fertilizers and pesticides.

During its 6th session in 1998, the UN Commission on Sustainable Development noted, that since Rio marked improvements in water quality had occurred in a number of river basins and groundwater aquifers where action had been taken. However, overall progress had not been sufficient to reduce general trends of deteriorating water quality and growing stress on freshwater ecosystems.

Concern over agricultural diffuse pollution sources in integrated water quality management has been growing recently. Such sources are likely to be even more critical in developing countries, including India, where agriculture and rural habitats are still dominant, unlike the G7 or other affluent industrialized nations. Pollution due to agricultural return waters, either as wash-off or as seepage, appears to be rare. However, surface wash-off of pollutants from agricultural sources becomes the dominant factor during flood flows, and seepage/drainage from agricultural fields/soils continues to pollute streams for a month or two after the monsoons are over. Application of chemical fertilizers and pesticides (or any other agricultural chemicals) in India is still low compared to developed countries, and while eutrophication due to high levels of washed-off nutrients is observed in rural ponds and other stagnant bodies of water receiving agricultural drainage, and excessive pesticide residuals are often reported for vegetables, fodder, milk, etc., monitoring of streams and rivers does not show any significant pollution due to nutrients or pesticides from agricultural diffuse pollution during fair weather months. The major problem of agricultural diffuse pollution appears to be the heavy silt loads, along with large quantities of dissolved salts, nutrients, organics and even heavy metals and bacterial contaminants washed off during floods. With the introduction of intensive agriculture and adoption of modern farming techniques involving the application of much irrigation water and agricultural chemicals, the problems caused by diffuse agricultural pollution are bound to grow (G.D. Agarwal, 1999).

Concern over agricultural diffuse pollution sources in integrated water quality management has been growing. Such sources are likely to be even more critical in developing countries, including India, where agriculture and rural habitats are still dominant. A number of special features of the Indian scene are considered: extremely varying rainfall and stream-flow patterns; still largely traditional agricultural practices with average application of fertilizers and pesticides and significant areas under dry farming or only marginal irrigational a very large cattle population, with agriculture almost always linked with animal husbandry; a culture of living close to the river with dominating in stream uses of wading, waste disposal; and respect for laws. Apart from disposal of industrial effluents on land and/or surface water bodies, untreated effluents are also injected into groundwater through ditches and wells in some industrial locations in India to avoid pollution abatement costs (Ghosh, 2005; Behera and Reddy, 2002; Tiwari and Mahapatra, 1999). As a result, groundwater's of surrounding areas become unsuitable for agriculture and/or drinking purposes. Continuous application of polluted surface and ground water for irrigation can also increase the soil salinity or alkalinity problems in farmlands.

Domestic wastewater has always been a low cost option for farmers to go in for irrigated agriculture in water scarce regions of the world. Apart from its resource value as water, the high nutrient content of domestic wastewater helps the farmers to fertilize their crops without spending substantial amount on additional fertilizers. Both temporal and spatial water scarcity, along with rising demand for water from competing sectors (growing population, urbanization and industrialization) have also forced the farmers to go for wastewater irrigation. However, safe utilization of wastewater for irrigation requires proper treatment and several precautionary measures in use, as it may cause environmental and human health hazards (Butt et al. 2005; Minhas and Samra, 2004; Bradford et al. 2003; Ensink et al. 2002; Vander Hoek et al. 2002; Abdulraheem, 1989). Environmental problems related to industrial effluent disposal on land have been reported from various parts of the country. Disposal on land has become a regular practice for some industries and creates local/regional environmental problems (Ghosh, 2005; Behera and Reddy, 2002; Biradar et al. 2002; Salunke and Karande, 2002; Kumar and Narayanaswamy, 2002; Barman et al. 2001; Singh et al. 2001; Kisku et al. 2000; Gowd and Kotaiah, 2000; Pathak et al. 1999; Tiwari and Mahapatra, 1999; Singh and Parwana, 1998; Kaushik et al. 1996; Narwal et al. 1992; Kannan and Oblisami, 1990).

Rapid industrial development in the last few decades has added huge loads of pollutants to our rivers (CPCB, 2004). Out of these pollutants, heavy metals are of major concern because of their persistent and bio-accumulative nature. These heavy metals may be of geological origin entering into the river system by weathering and erosion (Zhang and Huang, 1993) or anthropogenic due to mining, industrial processing, agricultural run-off and sewage disposal Abbasi et al. 1998). In the aquatic system a rapid removal of these heavy metals from the water to sediments may occur by settling particles while some of these pollutants can be mobilized by getting accumulated into the biota from the sediments sink (Lo and Fung, 1992). There are many different materials that may pollute soil or ground water. The changes in physico-chemical studies had been carried out in recent years at different places Nandurbar (Shrivastava 1995), Rourkela (ADAK 2001), Berhampur (Tripthy 1998), and Akola (Fokmare 2001). The ground water quality has been assessed by several researchers in the recent past (B.K. Gupta and R.K. Gupta 1999, M Raja Sekara et al. 2005, S.B. Thakare et al. 2005, Shika Bisht et al. 2007). Trace amount of metals are common in water and there are normally not harmful to human health. In fact some metals are essential to sustain life. Ca, Mg, K, and Na must be present for normal body fruitions. Co, Cu, Fe, Mn, Mo, Se and Zn are needed at low levels as catalysis for enzyme activity. The source of heavy metals in the urban area is divided in to two groups (1) natural sources and (2) anthropogenic sources (Chester, et al. 1989 and Sneddon 1983). The major sources of metals in ground water is waste disposal, pesticides, presence of pits type latrines result in accumulation of heavy metals and agrochemicals in ground water. The toxic effects of heavy metals are now well recognized and the toxic concentrations were very well studied. During the last decade an extensive database has been published providing a direct link between the exposure to low concentration of heavy metals and different diseases (Roshan, 1995). Heavy metals viz, Cr, Pb, Cd, Ag, Co, Ag, Hg, Ca and Sc are recognized highly toxic and dangers pollutant (Hoo et al. 2004).

However, continuous disposal of industrial effluents on lands leads to percolation of pollutants to the groundwater through seepage and leaching, causing contamination. As a result, farmers in the adjoining areas find the ground water unsuitable for irrigation. Drinking water wells may also get affected. Environmental problems related to industrial effluent disposal on land have been reported from various parts of the country. Disposal on land has become a regular practice for some industries and creates local/regional environmental problems (Ghosh, 2005; Behera and Reddy, 2002; Biradar et al. 2002; Salunke and Karande, 2002; Kumar and Narayanaswamy, 2002; Barman et al. 2001; Singh et al. 2001; Kisku et al. 2000; Gowd and Kotaiah, 2000; Pathak et al. 1999; Tiwari and Mahapatra, 1999; Singh and Parwana, 1998; Kaushik et al. 1996; Narwal et al. 1992; Kannan and Oblisami, 1990). There is substantial literature on benefits and costs of domestic sewage based irrigation practices (Scott et al. 2004; Keraita and Drechsel, 2004; Van der Hoek et al. 2002; Jimenez and Garduno, 2001; Qadir et al. 2000). However, the disposal of industrial effluents on land for irrigation is a comparatively new area of research and hence throws new challenges for environmental management (Buechler and Mekala, 2005; Ghosh, 2005, Bhamoriya, 2004; Behera and Reddy, 2002 and Tiwari and Mahapatra, 1999). Environmental and socio-economic aspects of industrial effluent irrigation have not been studied as extensively as irrigation using domestic sewage. Studies focused on different aspects of industrial effluent irrigation, with special reference to environmental, human health and livelihood impacts are rare.

In India, the supply of fresh water resources is almost constant and even if it is not falling, from which the agriculture sector draws the lion's share (80-90 per cent) (Kumar et al. 2005; Gupta and Deshpande, 2004; Vira et al. 2004 and Chopra, 2003). Hence, with the growing demand and rising scarcity for water, in future all the demands for agricultural use cannot be met by fresh water resources alone, but will gradually depend on marginal quality water or refuse water from domestic and industrial sectors (Bouwer, 2000). However, both domestic sewage and industrial effluents contain various water pollutants, which need to be treated before use for irrigation. Water quality is a key environmental issue facing the agricultural sector today. Meeting the right quantity and desirable quality of water for agriculture is not only essential for food security but also for food safety. Irrigation with untreated or partially treated wastewater and effluents could create environmental and human health hazards.

J.S. Pulle et al. (2005) assessed the quality of ground water of nanded city and inferred that the DO content of all ground water samples ranged from 3.08 to 6.28 mg/l. the lowest value was observed during summer while the highest values was found in winter months. Human waste and Industrial waste are the two important sources of oxygen depletion in water. It is estimated that 60-70% of water pollution is attributable to the discharge of sewage and other wastes from municipalities while remaining from industries. R.M. Singh and R.K. Trivedi (2005) studied the primary river quality of Tawa reservoir and reported that DO was alarmingly low in one of the sampling stations which is 1.5 mg/l. The council of environmental quality defines the threshold for water pollution alert as dissolved oxygen content of less than 5 mg/l of water. Moti R. Sharma and A. B. Gupta (2004) worked on water quality profile of Kunar-khad stream in outer Himalayas, India they reported DO content varied from 6.1 to 11.8 mg/l, which is within permissible limits. A. K. praharaj, B.K. mohanta and N.K. Nanda (2004) studied ground water quality of Reurkela, Orissa and found DO ranged between 5.6 mg/l to 6.4 mg/l. which was as per permissible limits. Amathussa et al. Stuelied physico-chemical and bacteriological status of tannery effluent polluted ground water in tiruchirapalli and found less do which is indicator of pollution of ground water by tanney effluent. J.D. Joshi et al. (2004) studied the drinking water quality of Patan region, Gujarat, India and reported DO ranges from 0.04 mg/l to 0.2 mg/l. depletion of DO in water supplies can encourage microbial reduction of nitrate to nitrite and sulphate. V. Sundari and R. Valliappan et al. studied quality of drinking water in and around Chidambarama taluk of ranged from 2.8- 4.42 mg/l. oxygen is the most vital factor for living beings to maintain metabolic processes. DO reflect the water quality. H.C. Kataria (2000) studied the quality of drinking water of Pipariya town ship and reported that depletion of DO from water in summer is due to high temperature and increased microbial activity. Kataria (1990) noted DO 0.18 mg/l to 9.6 mg/l in bore well water of Bhopal.

Nitrate is held in the soil in solution and is thus vulnerable to downward movement (leaching) whenever water moves through the soil. The potential for leaching depends on soil type and structure with greater risk in free draining soils. There are interactions with weather (rainfall volume and pattern), soil and crop management. The amount of N in the soil is also an important factor. Crop rotation plays an important role and nitrate leaching has been described as an inevitable result of crop production (Goulding, 2000). Crops such as potatoes and oilseed rape are considered high risk crops for nitrate leaching (Shepherd & Lord, 1996; Johnson et al. 2002). This is related to their N balance (much more nitrogen is applied to these crops than is removed in produce) and the rapid decay of the remaining foliage that releases nitrate which will be at risk of leaching. Brassica crops also fall into this category.

The World Health Organization has adopted a 10 ppm nitrate-N maximum standard for safe drinking water, but this worldwide standard is often exceeded. Groundwater nitrate contamination associated with fertilizer use is common in both developed and developing regions (Oenema et al. 1998; Agrawal et al. 1999). Even in the US, where the Safe Drinking Water Act regulates this standard, regional studies suggest that 10–20% of groundwater sources may exceed 10 ppm. Severe instances of groundwater contamination are often associated with livestock production in CAFOs, particularly swine and poultry (Mallin 2000). Groundwater contamination by nitrate may be a particularly serious problem due to its poor reversibility (van Lanen and Dijksma 1999). The potential health effects of high nitrate levels are diverse, including reproductive problems (Kramer et al. 1996), methemoglobinemia, and cancer. Infants are especially at risk for methemoglobinemia ("blue-baby" syndrome), and while little conclusive evidence exists for this disorder occurring where levels are below 10 ppm, higher values found throughout the world can significantly elevate the risk (Gupta et al. 2000). Some health professionals also believe that methemoglobinemia may often be under-or misdiagnosed (Johnson and Kross 1990).

Livestock and manure production are often a major factor in the diffuse pollution of nitrate (Chambers et al. 1999). Where livestock numbers are very high relative to the land area for spreading, the amount of nitrogen applied either immediately during grazing or later as organic manures leads to excessive soil nitrogen which is vulnerable to leaching. Sewage sledges and composts can also be significant sources of nitrogen and phosphate.

Phosphorus pollution is of concern due to its contributory effect on causing eutrophication of surface waters. Small increases in P concentration can cause the eutrophication (nutrient enrichment) of fresh waters which, in turn, can cause algal blooms, fish death, excessive weed growth, poor water clarity and loss of species diversity. Where phosphorus concentrations are high, there can be increased filtration costs before the water is suitable for drinking. Apart from agriculture, wastewater from sewage treatment works is a significant source of P pollution of waters. This must be borne in mind when considering mitigation measures for controlling P pollution.

The process of P transfer to water differs fundamentally to that for nitrogen. On agricultural land, high-risk areas for P loss are the riparian zone due to its more consistent hydrological consistency, and upslope areas if there is good water connectivity between the source and the point of final impact in the watercourse, for example via under drainage schemes or along road culverts (Mainstone & Parr, 2002).

Although soil *'in situ'* is not a pollutant, once it enters water systems in large amounts, it can cause siltation. This can have serious detrimental effects on wildlife, such as the death of juvenile fish (MAFF, 2000). Waters which have high sediment loads may need to be treated which will add significant costs to abstractors such as fish farms or drinking water supplies. As for phosphorus, the high-risk area for sediment loss is the riparian zone or upslope areas if there is good water connectivity.

Research over the last few years has greatly increased understanding of pesticide fate following application to agricultural land. As a result, the importance of diffuse pathways of surface and groundwater contamination has been widely recognized. Diffuse sources generally comprise those situations where pesticides are applied for agricultural and non-agricultural purposes on a field scale to land where a microbiologically active soil layer is present and where degradation and dissipation processes can take place. The active substance and/or its metabolites may have the opportunity for soil/sediment accumulation, uptake by crops/plant/non-target biota before moving through the soil layers in solution or sorbed to soil particles. Solutes or absorbed material can enter water via artificial drainage systems or as surface or sub-surface flow, leaching or bypass flow. Groundwater and surface water bodies can be affected. Spray drift and pesticides in precipitation can also be considered to be a diffuse source of surface water contamination (PEWG, 2000). The significance of these pathways of pesticide transport varies according to the nature and properties of the compound and the soil, the antecedent/prevailing soil and crop conditions, the topography of the land, geological characteristics and land treatment practices (Carter, 2000). For example, losses of applied pesticides from fields to surface waters via drainage are strongly controlled by timing, amount and intensity of rainfall events. A number of studies (e.g. Brown et al. 1995) have shown that the mass of pesticides leached is inversely proportional to the time elapsed between pesticide application and the first infiltration event (Flury, 1996).

Biochemical oxygen demand is an indication of the levels of organic materials in a water sample. Oxygen depletion is linked to organic materials because bacteria which are present naturally in the sample will metabolize the organic materials and in doing so consume oxygen. BOD is not a specific measure of pollution from agricultural sources food processing facilities, industrial processes and even recreational water use can all adversely affect a BOD determination.

Watershed management for any city requires the estimation of both point and non-point sources of water pollution. An effective land-use planning plays a crucial role in efficient management of water resources of any area. Both diffuse and point source pollution is dependent upon the land use pattern of a city. The total amount of runoff generated from an area depends upon the land use type of that area. High impervious area in a city results in more runoff generation thereby allowing more pollutants to enter into the surface water bodies directly and indirectly. Similarly the point source pollution of water is also dependent upon the landuse pattern of the city. Densely populated city like National Capital Territory (NCT) of India will generate more domestic sewage. Also, urban runoff on percolation results in salinization of the groundwater (Ma J. et al. 2009). The poor quality of surface waters can also be attributed to the runoff generated from both dry and wet weather (Wenwei et al. 2003; Taebi and Droste, 2004; Petersen et al. 2005; McLeod et al. 2006). Different factors contributing to the quality of urban runoff have been studied and it has been concluded that surface water quality is indeed affected by urbanization and industrialization (Al-Kharabsheh, 1999; Karn and Harada, 2001; Wang, 2001; Marsalek et al. 2002; Kelsey et al. 2004; Jamwal et al. 2008).

Different types of pollutants are generated from different land use type. In a city like Delhi, the nonpoint pollution generated from the domestic land use type (residential) are organic in nature therefore it's important to measure the BOD, COD and DO of the urban runoff from a domestic site. Other parameters which are generated in storm water runoff from a land use with both industrial and domestic activity are nitrogen and its compounds, phosphates, chlorides, sulphates and solids. The storm water runoff from an agriculture land use type may contain pollutants which are both organic and inorganic in nature therefore for the present study the chosen parameters are as follows: pH, BOD, COD, DO, TKN, TDS, TSS, Nitrates, Chlorides, Fluorides, Sulphates, Hardness, Ammonia and Phosphates. Hence, analysis of changes in land use pattern provides vital information for developing strategies for water pollution control for an existing old city (Roy et al. 2008).

Metals occur naturally and become integrated into aquatic organisms through food and water. Trace metals such as mercury, copper, selenium, and zinc are essential metabolic components in low concentrations. However, metals tend to bio-accumulate in tissues and prolonged exposure or exposure at higher concentrations can lead to illness. Elevated concentrations of trace metals can have negative consequences for both wildlife and humans. Human activities such as mining and heavy industry can result in higher concentrations than those that would be found naturally. Metals tend to be strongly associated with sediments in rivers, lakes, and reservoirs and their release to the surrounding water is largely a function of pH, oxidation-reduction state, and organic matter content of the water (and the same is also true for nutrient and organic compounds). For example, metal concentrations in Lake Mashu in Japan tended to be elevated near the bottom of the lake where oxidation-reduction states are usually high. Thus, water quality monitoring for metals should also examine sediment concentrations, so as not to overlook a potential source of metal contamination to surface waters.

Post-World War II developments in the petrochemical and pharmaceutical industries have provided many new chemicals that offer improvements in industry, agriculture, and medical treatments. New compounds have also found applications as household and as personal care products. These substances enter the environment, disperse, and persist to a greater extent than initially anticipated. They can enter the environment intentionally through measured releases, for instance with pesticide application in agriculture; in permitted and unregulated releases of the by-products of industrial processes; or directly as household waste, which can contain cleansers, personal care products, pharmaceuticals, and biogenic hormones. Further, intensive agriculture makes use of feeds that contain veterinary pharmaceuticals. These agrochemicals are present in animal waste and are released into the environment accidentally through spills or damaged holding facilities or intentionally as a soil treatment (Kolpin et al. 2002; Fox, 2001).

Little is known about the prevalence, distribution, and ultimate fate of many of these compounds and their breakdown products. Part of the reason for this lack of knowledge is that, until recently, analytical tools that could detect these substances at levels that would be expected in the environment were not available. The potential concern from the environmental presence of these substances is the development of abnormal physiological processes and reproductive impairment in exposed humans and wildlife, increased risk of cancer, the development of antibiotic-resistant bacteria and the potential for increased toxicity when these compounds mix (Kolpin et al. 2002). Moreover, the presence of new chemicals in aquatic ecosystems has the potential to alter natural biogeochemical fluxes in the environment, with unknown consequences.

Recent studies have shown that chemicals used in agriculture, industry, households, and for personal care are making their way into the environment and that many of them are suspected endocrine disruptors. These chemicals include PCBs, pesticides, disinfectants, plastic additives, flame-retardants, and pharmaceuticals (e.g. birth control pills and epilepsy medications). Some of the effects on wildlife that have been attributed to endocrine disruptors include thinning of eggshells in birds, toxicity in embryos, inadequate parental behavior, malformations, cancerous growths in the reproductive system, and feminization of male offspring. The effects of exposure of endocrine disruptors in humans are unclear but investigations using animals and studies from wildlife populations suggest that that there is cause for concern (Markey et al. 2002).

Several researchers have carried out studies on ground water of different parts of the country, but very little work has been carried out for Vindhya Pradesh. In the present study diffuse chemical pollution of ground water in the Vindhya Pradesh region was investigated this includes six Districts.