Pollution in the Mahanadi: Urban Sewage, Industrial Effluents and Biomedical Waste

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The discharge of municipal sewage, industrial effluents and biomedical waste into the Mahanadi has raised concerns about environmental sustainability and also posed a serious threat to the health of people living on the banks. This article critically examines the river pollution caused by the spiralling urbanisation and industrialisation along with dumping of waste by many medical facilities. There is an urgent need to address this enormous challenge which is a direct outcome of inefficient planning and management.

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In Orissa, as a result of the population influx into urban areas and industrialisation, the water withdrawals from rivers, lakes and reservoirs have increased fourfold in the last two decades; the discharge of wastewater into water-bodies far exceeds the self purification capacity. Industrial chemicals and hazardous effluents and raw domestic sewage are the two main pollutants of rivers. In addition to this is the threat from the biomedical waste of the growing healthcare facilities.

Microbial pollution or contaminated water is believed to be the largest single cause of infant mortality and diarrhoea the single highest cause of work days lost. The other diseases resulting from stagnant water and polluted environments are gastro-enteritis and cholera, typhoid, viral hepatitis and malaria including increasing incidences of brain malaria.

1 Introduction

The Tenth Five-Year Plan by the government of India emphasised supply of adequate and safe drinking water to the entire population, to clean up the major polluted rivers and their catchment areas. Accordingly, the National Water Policy (April 2002) and Orissa State Water Policy (SWP) 2007, give priority to the allocation of water resources for drinking water, irrigation, and hydroelectric power, in that order.

Orissa, with its large mineral resources, particularly coal (58 billion tonnes, i e, 25 per cent of India's total), iron (25 per cent) and bauxite (50 per cent), chromite (127 million tonnes (mt) of the 140 mt in India), manganese, graphite, dolomite and limestone combined with the potential for port infrastructure, is poised to emerge as the metal, mining and a manufacturing hub in the country. However the recent tide of industrial houses – some serious and some not so serious – wanting to ensure a piece of the state's multi-mineral riches has raised serious concerns over environmental sustainability, specifically pertaining to pollution management and water resources. Water use for industries comes fifth and second last in the Orissa SWP 2007 but conflicts over water resources for irrigation and industrial use have already begun in the state.

Domestic Waste Discharge

The Mahanadi running through 494 km within Orissa with five main tributaries and four major distributaries is the largest river system among the 11 rivers in the state. It has a basin area of 65,628 sq km with a population of 1.62 crore projected to rise to 2.9 crore in 2051 when the population is expected to stabilise. There are about 34 cities, towns and urban conglomerates in the Mahanadi river basin area inside Orissa. Among others, those heavily populated and directly polluting habitations are Sambalpur, Choudwar, Cuttack and Paradeep. The Orissa Pollution Control Board (OSPCB) estimates untreated domestic wastewater discharge from urban settlements in the Mahanadi basin at 3,45,000 m^3 (m^3 = 1,000 litres) per day, contributing a biochemical oxygen demand (BOD) load of about 68.8 tonnes every day.

Under the Water (Prevention and Control of Pollution) Act 1974, which governs water quality management in the country, monitoring stations on all major rivers test pollution levels on various parameters monthly, quarterly or annually. From the 18 monitoring stations for Mahanadi and its major distributaries that OSPCB operates, averaging readings over four years from 2002 to 2006 found that in most stretches of the river the critical parameters which determined water quality, were of organic origin, reinforcing the findings of this study that urban domestic waste discharge is emerging as a more urgent concern than industrial effluent disposal into Mahanadi.

Due to the high organic and bacterial pollution indicators (the total and fecal coliform (TC and FC) and (BOD), the downstream/stretches, which are also water intake stretches of major towns and cities, have been downgraded severely. The water intake stretches for Sambalpur and

Cuttack have been downgraded to grade D/E and that of Paradeep to below grade E because of additional pollution indicators – EC, SAR, and chloride coming from industrial effluents.[1]

2 Open Sewage

A population currently at 1.62 lakh (1.54 lakh in 2001 Census), and prospectively at 4.35 lakh in 2011 [Orissa Water Supply and Sewerage Board 2007] Sambalpur town saw a decadal growth of 66 per cent in 1971, 70.5 per cent in 1981, slowing down to around 19 per cent in 1991 and 35 per cent in 2001. Inward migration for employment in industries and ancillary establishments has resulted in growing slums. Around 60 per cent of the present population lives in 101 slums within the 33.6 sq km municipality area.

Sambalpur town's western flank discharges the entire town's untreated sewage from 12 outfalls within a 5 km stretch directly into the Mahanadi. In summer when the Hirakud dam discharges next to nothing, the river water with the sewage stagnates in patches between overgrown weeds and riverbed rocks. This is the only bathing and clothes washing option available to thousands of people living by the river including pilgrims to the riverside shrine of Samalai.

The open sewage system of Sambalpur Municipal Corporation (SMC) consists of seven minor drains and three major nullah or natural watercourses which meander 10 to 22 kms each, inside the town, collecting sewage. The major sewage outfall is through one of these – the Dhobijore. In 1999 it dumped 129.6 kilolitres per day (KLD) of sewage into the river.

Water Quality

A remarkable and sudden deterioration in water quality just after the sewage outfall is telling. While Sambalpur upstream shows low BOD of 1.1 mg/l; just 5 km downstream at Dhobijore, it deteriorates to 3.1 mg/l. Similarly TC is 2,650 MPN/100ml upstream but deteriorates nearly 14 times to 36,742 MPN/100ml downstream. The pressure of rising population density on water pollution levels too is growing. In 2000, annual average TC downstream was 15,478 MPN/100ml; six years later, in 2006 it had more than doubled to 36,742 MPN/100ml. The OSPCB classifies the water quality of Sambalpur downstream (also public water supply intake point) as class D and E.

Dhobijore being the lowest point in the topography hereabouts, river water is deepest here. Barely 15 ft from the sewage outfall is the public water supply intake point. The inadequate piped water supplied to the municipal area is supplemented by 674 stand posts and 446 hand pumps. Sambalpur area has a granite basement; at some points the water table remains high unable to percolate because of the rock base. These points are penetrated for tube and dug-wells and also become the pathways for sewage contamination of groundwater since water remains barely 10 feet below the surface.

The 5 km long main discharge drain, which runs at the inner foot of the ring-road to transport the sewage in the final leg to the outfalls, has been long since inoperative and overgrown with shrubs. Open drains and dug-outs that fed this arterial drain from colonies are stagnating, alive with worms and leeches, overflowing into homes and even temples, polluting groundwater. Colitis, gastro-enteritis (transmitted primarily through human faeces) and viral hepatitis are the result, but malaria takes the heaviest toll.

Added to the raw sewage, "open defecation is a curse in Sambalpur town", admits Sachinanda Satpathy, assistant engineer with the SMC. The existing "free-use" toilets lie unused. In a town with literacy levels of 76.28 per cent this acute lack of sanitation sense and further inability of authorities and non-governmental organisations (NGOs) to inculcate awareness is surprising.

At the receiving end of public brickbats, the UIDSSMT has at last come to the rescue of the SMC. Under the scheme the existing dysfunctional ring road drain will be redesigned to cover 4,600 metres and 24 10-seater public toilets will be built, together costing Rs 5.93 crore. It is a paradox that while existing free toilets have no takers, the UIDSSMT proposal visualises a daily user fee revenue of Rs 15,000 from the toilet utilities, expecting that many users.

3 Cuttack: A City of Drains

More than a 1,000 years old, the erstwhile capital of Orissa, Cuttack, is virtually tottering over its drains, particularly during the three months of monsoon when many areas remain knee deep in water and the drains invade kitchens and bedrooms. Until recently, Cuttack's faecal disposal was through manual scavenging. Hence its 20-year-old sewage networking of just 19 kms covers only 10 per cent of the city.

Urban growth in Cuttack expanded rapidly in the 1960s after development of the Paradeep port and construction of connecting flyover bridges. Two planned housing settlements with populations of 10,000 and 1.5 lakh came up on the banks of Mahanadi and on the western tip of the Mahanadi-Kathajodi rivers bifurcation. While the latter has a 4.5 million litres per day (MLD) STP the former drains its sewage directly into Mahanadi.

In most areas, household sewage is flushed or washed into the open roadside drains. The 192.5 sq km Cuttack Municipality Corporation (CMC) area has a total of 1,678 kms of drains, which lead to the two main open storm water drains, together 22 kms long. An additional 29 kms of branch storm water channels complete the currently available drainage (and sewage) infrastructure in the city. Broadly speaking, domestic waste water, solid waste and sewage have a single disposal channel. Clogged drains, year round overflow into alleys and critical water logging in monsoons are the result.

The present daily sewage flow is 120 litre per capita day (lpcd-calculated at 80 per cent of water supply) from a city population of 5.35 lakh (Census 2001); sewage generation is projected at 88.54 mld in 2011 with the population increasing to 6.51 lakh, 105.59 mld in 2021 with population at 7.93 lakh and 160 mld in 2041 with population at 12.46 lakh. Ponds and low areas which could moderate storm water flow are now all built up.

In 2001 the Pollution Abatement Scheme (PAS) for Mahanadi under the National River Conservation Programme (NRCP) was implemented in Cuttack. Besides the Mahanadi and Brahmani, 27 other polluted rivers running through 149 towns in 16 states also came under this scheme. The total approved cost of the programme was Rs 3,080 crore and slated to be completed by December 2005.

Delays and the Choking

In Cuttack the PAS sought to reduce pollution from city domestic wastes and effluents from the Jagatpur industrial area that drains into Mahanadi, its distributory Kathajodi and the Taladanda canal, which is the main irrigation source and bathing ghat for villages along its length.

After furores in the state legislative assembly over the delay, in December 2006, the implementing agency, Orissa Water Supply and Sewerage Board of the department of urban development, the government of Orissa completed and handed over to the CMC, five sewage interception and diversion points. These are sewage collection points from which the waste is pumped out into the two main storm water drains which then carry it to the 33 mld sewage treatment plant (STP) at Matagajpur, located on the Kathajodi river bank. The STP was handed over in January 2007; CMC floated bids to operate and maintain the STP in September 2007, but till date a technically suitable agent has not been decided upon. The STP idles while the rivers choke with the city's sewage characterised by BOD 160 mg/l; COD 250 mg/l; suspended solids 158 mg/l and coliform count of 1,00,00,000 MPN/100ml, (discharges are assumed to be diluted 10 times in water bodies). With 30 low cost public toilets OWSSB's total bill was Rs 6.84 crore.

After two years time over-run, work under the NRCP is not yet complete. According to member secretary, OWSSB, Dilip Kumar Padhi:

> The lack of gradient in Cuttack is our major obstacle to delivering on time. In some places we had to dig to a depth of 23 feet to get the required gravity flow. The high water table throws up water even at 8 ft depth at places which has to be pumped out simultaneously for work to continue; all this renders progress slow.

The Orissa government made a special request to include Cuttack city under the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) which originally included only Bhubaneswar and Puri. The project scope under JNNURM in Cuttack city includes a 242 km sewage network, 10 pumping, nine lifting and six main pumping stations, three more STPS with a total of 52.18 mld at a cost of Rs 345.03 crore (including cost of 51.93 hectares of land for STPS and pumping stations). After the projected completion in 2012, just a year's cost for operation and maintenance of the above is estimated at a huge Rs 7.45 crore. The present municipal sewage user fee of Rs 20 a month would thereafter see a large hike to render this infrastructure viable.

However, one basic lacunae in planning however remains – while officially Cuttack city's population is expected to reach 6.51 lakh in 2011, unofficial, reports say that, it is already nudging seven lakh.

4 Industrial Pollution

Based on pollution potential the ministry of environment and forests, GOI have colour categorised industries as red, orange and green. Orissa has 65 per cent of red or potentially most polluting industries, most of them engaged in primary manufacturing; 20 per cent of orange and 15 per cent of green. These are again classified as grossly polluting, based on their water polluting load, i e, if it exceeds BOD count of 100 kg/day or if its effluent contains hazardous chemicals. Orissa has 18 such industries.

There are 15 large industries in the Mahanadi basin, aluminium and thermal power plants at Hirakud, charge chrome and power plant at Chowdwar, paper industry in Jagatpur and two fertiliser plants in Paradeep which discharge effluent into Mahanadi directly. The total industrial effluent released into the Mahanadi at Sambalpur, Cuttack and Paradeep from the larger units are 736 KLD, 2,780 KLD and 5,280 KLD respectively.

Several medium and small industries on the Mahanadi basin discharge 1,00,000 m^3 of waste water every day; 12 coal mines discharge 14,000 m^3 mine water daily during non-monsoon months. Agricultural return waters amount to 1,564 million m^3 but since fertiliser and pesticide use in Orissa is not high; the pollution from agricultural sources is not alarming. There are a number of other proposed industries to come up on this river basin.

The entire amount of industrial wastewater however does not go into the river system. Some of it is diverted to marshes and other natural detention basins. In contrast to the almost complete absence of infrastructure to treat domestic sewage, industries (particularly the large ones who, over the last two to three years, are expanding production capacity), have simultaneously endeavoured through advanced technologies and substantial investment to maximise reuse of wastewater and also to improve characteristics of discharged effluent.

One of the drivers of this positive change is the National Policy for Abatement of Pollution, 1992, and the Charter on Corporate Responsibility for Environmental Protection (CREP), 2003. Both seek pollution control through various measures including waste minimisation, in-plant process control and adoption of clean and feasible technologies rather than end-pipe treatment. The other triggers for change is the partnership through technology and investment with foreign companies; an increasing global scrutiny and pressure on national governments to address climate change issues; and last but not the least a fairly proactive media and judiciary.

Though declining, instances of and the potential for industrial water pollution under the existing infrastructural still remains. It may however be mentioned that in almost all the industries visited for this study and generally, in Orissa, air pollution is emerging as more of a concern than that of water pollution.

5 Industry's Negligence

One of the biggest producers of primary aluminium in Asia, Hindustan Aluminium Company (HINDALCO) Industries' integrated aluminium plant (smelter plant and captive power plant) is located at the Mahanadi head in Hirakud, 5 kms from the dam and 12 kms from Sambalpur town. HINDALCO's smelter plant in Hirakud is certified ISO 14001 (for exemplary work in practising environmental management). It has installed most required pollution control systems.

In November 2007 the Sambalpur regional office of the OSPCB slapped a case against HINDALCO, for discharging effluent from its smelter plant site that contained eight times more fluoride than permissible limits, not into its designated outlet but into Kharjor nullah. A major natural creek it runs adjacent to the plant and drains into the Mahanadi river, and is used by the local population for domestic purposes. Fluoride tolerance limits for any class of water is 1.5 mg/l.

As is being seen once too often, pollution from industries results not so much from non-instalment of mandatory pollution control equipments as much as from lack of good practices and vigilance.

Fluorides that accumulate in aquatic organisms can work their way into the water table. Too much fluorine in water can lead to dental fluorosis during critical tooth development period in children less than six years of age and, on a longer-term basis, to osteoporosis.

Earlier in 2006, contesting HINDALCO's ISO 14001 certification, a Bhubaneswar based NGO Vasundhara scientifically substantiated its allegations in their report *Ecological, Socio-economic and Health Impact Assessment Due to Aluminium Smelters – A Case Study of Hindalco in Orissa*.

The authors Aruna Murthy and Himanshu Sekhar Patra observe that:

> The Kharjor nullah...carries all the industrial effluent with it. As there is no polythene lining in the hazardous waste disposal site (or sludge pond), the leachate generated from the site is directly carried into the nullah. Similarly during monsoon period, the storm water from the hazardous disposal site is carried out by this nullah. ...Various parameters such as the sulphate, turbidity, fluoride and iron content of this nullah and the water collected from the plant site were found to be high.

Nuajamuda village, 500 metres away from the industry has been partially affected due to the leakage of chlorine gas from HINDALCO in 2003. The Vasundhara report alleges that HINDALCO deliberately switches off its ESPs during the night to save on electricity consumption, a practice not uncommon among industries all over the state.

Abhijit Pati, of HINDALCO explains away the November 2007 fluoride detection by the SPCB as nothing but a run off from ongoing construction work within the plant premises carrying the fluoride dust with it, but admits that they are yet to install a fluoride treatment plant which is the principal stipulation of the regulatory authority in the present case.

6 Fertiliser Plants

The only two large fertiliser plants in the state are in Paradeep the port town, as most of their raw material is imported. Paradeep Phosphates (PPL) and Indian Farmer's Fertilisers Cooperative (IFFCO) produce 3.0 mt of di-ammonia phosphate (DAP) fertilisers. Their effluent load on Mahanadi is 5,280 KLD released into the Atharbanki creek of Mahanadi. Their total industrial pollution load on Mahanadi is BOD at 15 kg/d, COD at 35kg/d and oil and grease (O&G) at 7.5 kg/d. The town's untreated domestic sewage too drains into the creek.

The water quality at Paradeep, according to OSPCB does not qualify even for class E due to several parameters like TC (annual average in 2006 was 17,386 MPN/100ml); EC (2,412 microsiemen/cm in winter 2006; tolerance limit for class E water is 2,250); SAR (31.06 in April 2006; sodium absorption ratio – indicates the concentration of sodium; tolerance limit for class E water is 26); Chloride (3,497 mg/l in April 2006; industrial effluents may carry chloride; at 250 mg/l gives salty taste, 600 mg/l is the tolerance limits for class E water; at very high concentration can be toxic to crops), TKN (39.8 mg/l in April 2006; indicates higher level of ammonia, 0.2 to 2.0 mg/l can be lethal to some variety of fish).

The pollution scenario in the industrial port town of Paradeep is significantly improved after one of the two fertiliser plants Oswal Chemicals and Fertilisers (OCFL) was acquired by IFFCO in October 2005. Both PPL and IFFCO have installed improved technologies and have better technical manpower now; not only has dangerous air and water pollution been cut but increasingly more waste water is being reused.

The process of the production of DAP has a high pollution potential. Phosphoric acid is produced when the mineral rock phosphate is mixed with sulphuric acid. The phosphoric acid thus produced is again mixed with ammonia gas, and DAP fertiliser is ready. The potential water pollutants come from mainly leakages, spillages and washings from the sulphuric and phosphoric acid plants as well as effluents from the captive power plants.

Gypsum: A Pollution Hazard

The main water pollution concern today is the growing pile-up of gypsum (calcium sulphate) from the two industries. For every tonne of sulphuric acid produced, 5 tonnes of phospho-gypsum is generated as by-product. PPL's gypsum pond is spread over 100 hectares and IFFCO's over 70 hectares. Much of the wastewater of both industries is recycled in the gypsum slurry and settling ponds and infrastructure is in place to arrest overflow. The phosphoric acid in gypsum is corrosive to most construction materials. To prevent leeching the gypsum pond is lined with bentolite clay (PPL) or PVC (IFFCO). But heavy machinery scooping out settled gypsum damage the PVS lining and cause acid leaks

PPL generates 15 lakh tonnes of dry gypsum and is able to sell only a fifth of it. Its gypsum pond dykes are now 15 metres high and can go up to a permissible 35 metres. Dry gypsum is used in the manufacturing of cement, plaster of paris and gypboards; also for amelioration of alkaline soil; Utter Pradesh is a buyer and recently the Orissa government too has announced utilisation of gypsum for this purpose. Maintaining discarded gypsum ponds is a high financial burden; gypsum hillocks are a pollution hazard to which not even developed countries have found a safe solution.

Being a coastal town, the area sees heavy and prolonged rainfall. The rainwater carries with it gypsum acid leaks and overflows, run-off from industry's buildings and grounds into the factories' storm water drains which discharges into Atharbanki creek and then into the Mahanadi.

7 Need for Communication

One reason why industries are facing such stiff resistance in Orissa and elsewhere today is because far decades little sincere effort was made to involve citizenry in (environmental) information sharing or making its access easy, leave alone decision-making. For instance, a senior member of the OSPCB states how, at an environmental impact assessment public hearing before land acquisition for an industry he himself failed to understand the translated contents (into the regional language) of the environment impact document. These mandatory public hearing are often used as forums for advocacy on behalf of industries – painting alluring pictures of development and employment; communities use them to demand jobs and land compensation.

According to a Lady Sarpanch, Smitarani Swain, 2 kms as the crow flies from the IFFCO plant site is its adopted village Nuagada. As part of its CSR it is promoting self-help groups by giving away goats and agricultural equipments, but neither the panchayat nor the sarpanch were ever consulted. In Sandhakoda, a large fishing community living cheek by jowl to the PPL's compound wall, there is a deeper sense of exclusion. Twice, only through rumours of gas leaks, they evacuated without any official communication. The high compound wall figuratively denotes a wall of non-communication, even though pollution impacts, small or catastrophic are borne directly by these communities.

The issue of environmental compliance has become an arbitrary business between the regulator and the regulated, leading to corruption and increased judicial and citizens' activism to protect situations from breakdowns. Sit-ins, demonstrations and peaceful rallies are commonly resorted to by communities. In recent times, two case studies which succeeded in bringing significant positive change in Orissa can be noted.

8 Accountability

In 2002, project Swarajya, a Cuttack based NGO filed a public interest litigation (PIL) against OCFL for polluting against norms and made a party to the violation the secretaries, departments of forest and environment and fisheries and animal development, government of Orissa, the union of India and the chairman, OSPCB for failing to ensure compliance to norms of OCFL. Ever since OCFL, a Rs 2,000 crore fertiliser plant, producing 2 million tonnes per annum of di ammonia phosphate, one of the largest producers in India which started production in April 1999, faced a host of complaints and agitation from local people over water and air pollution.

Despite three major accidents, a number of ammonia gas leaks and one that destroyed 3,500 hectares of ripening paddy, and a few Orissa State Pollution Control Board (OSPCB) raps, the industry carried on with seeming impunity. Probably it may have continued for some years. The PIL resulted in heated debates in the state legislative assembly and the formation of an environmental committee headed by the speaker. Finally, after more than six closures in that many years, the company decided to sell out to IFFCO.

Orissa has only recently woken up to the horrors of insensitive biomedic waste management after the body parts of female foetuses were found near a private clinic in Nayagarh district. But discontent had been building up since long. A PIL was filed in the Orissa High Court in 2003 by Rabinarayan Mohapatra, on behalf of a Cuttack based NGO, Maitree Sadan alleging that three government medical colleges and hospitals-1208-bed Sriramchandra Bhanja Medical College and Hospital, Cuttack, 881-bed MKCG Medical College and Hospital, Berhampur and 772-bed VSS Medical College and Hospital, Burla, Sambalpur were disposing medical wastes in violation of the Medical Waste Management Rule 1998, thereby posing a serious threat to the health of the people.

Much to be Desired

Acting on the petition, the court then directed the OSPCB to monitor the process in which the medical colleges were disposing wastes and take action as per rule. Observing inaction the court sought a report from the regulatory body on the state of pollution in these hospitals. Dissatisfied with the report the court then appointed two retired judges to field investigate; they declined on health grounds. More than three years had elapsed. Finally in mid-2007 a single bench judicial commission of enquiry was constituted. Based on its interim report the defaulting government institutions have recently installed individual waste treatment facility comprising of incinerators, microwaves and shredders. The operations of these facilities are, as of now, under observation.

Management of biomedical waste, including wastewater still leaves much to be desired, not in SCB Medical College alone but in Cuttack city itself, as it is the medical hub of Orissa. Officially, the city has one medical college and hospital, six medical units, nine private hospitals (including exclusive cancer treatment facilities), 23 dispensaries, nine nursing homes, two veterinary hospitals and many unofficial one-room private clinics.

About 16 kms from Sambalpur town, on the right bank of Hirakud dam with population of 39,188 (2001 Census) is Burla Notified Area Council. The 48-year-old VSS Medical College and Hospital here caters to lesser numbers but is equally vital to the district populace. The medical wastewaters partly drains into a pond in the Kirba mouza and partly into the Hirakud dam's electricity power channel, which connects directly with Mahanadi flowing down to Sambalpur. Today, almost 5,000 people in Burla use this power channel water for domestic purposes; they also drain their sewage into it. Here, as in Cuttack and elsewhere it is the same plaint from persecuted authorities – there is an acute shortage of technically trained manpower and agencies for waste management.

Sithikantha Sahoo, regional officer of the SPCB, Sambalpur asks, "On paper medical waste disposal systems may appear adequate, but supervision is poor. Whether the sweeper is actually carrying the solid wastes to its designated pit or throwing it on the closest roadside dump, is someone checking that?"

9 Conclusions

What poses a major challenge for the regulatory authorities is that in black and white record, equipments in both industries and medical facilities are in place; the crux lies in their operation, use and practice. It becomes next to impossible, for instance, for altogether one regional officer and two technical inspecting staff at the Sambalpur SPCB to monitor, let alone keep constant surveillance over 800 small and large industries spread over eight districts under their jurisdiction. Even when violators are booked, there are political and bureaucratic patrons who will often either stall the prosecution or bail them out. The regulatory bodies urgently need to be strengthened with more autonomy and infusion of technical human resource, given the rapid growth in industrial activity in the state.

NOTE

1 Used Based Classification of Water:

Class A: drinking water source without conventional treatment but after disinfection, class B: outdoor bathing, class C: drinking water source with conventional treatment followed by disinfection, class D: fish culture and wildlife propagation, class E: irrigation, industrial cooling or controlled waste disposal.

Water Quality Parameters:

Physical Parameters: Temperature, pH (a measure of acidity, neutral water has pH of 7; low pH indicates high acidity), alkalinity (a measure of water's capacity to neutralise acidity), total suspended solids (TSS, refers to larger settleable solids, higher TSS gives problems of filtration and disinfection). Indicators of Organic Pollution: Dissolved oxygen (DO, water require sufficient dissolved oxygen to avoid onset of septic conditions and malodours. So the more organic pollutants in water, the more oxygen they use up. Traditionally, waste treatment required oxygen demanding materials so as to maintain dissolved oxygen content in water. Minimum mg/l: class A-6.0, class B-5.0, class C-4.0, class D-4.0); biochemical oxygen demand (BOD, most industrial and municipal waste contain high concentration of organic substances. Their presence encourages the growth of decomposers which consume large quantities of oxygen. Less dissolved oxygen will mean less decomposition and continued contamination, BOD is a measure of the contamination of wastewater. Maximum tolerance limit mg/l: class A-2.0, class B-3.0, class C-3.0), chemical oxygen demand (COD, chemicals in wastewater react with oxygen-oxidisation, and deplete dissolved oxygen maximum limit-250 mg/l); free ammonia – nitrogen, total kjeldahl nitrogen (TKN). Bacteriological Parameters: Pathogen microorganisms which are potentially transmittable to man through drinking and bathing. Total Coliform (TC, indicator of bacterial contamination, maximum MPN/100ml: class A-50, class B-500, class C-5000; acceptable limits: less than 2000) and fecal coliform (FC, indicator of fecal contamination; acceptable limits less than 2000 MPN/100ml). Mineral Constituents: electrical conductivity (EC indicator of excess dissolved solids in wastewater), total dissolved solids (TDS tolerance limits: class A-500mg/l; class E-2100mg/l), boron, sodium absorption ratio (SAR), hardness, chloride, sulphate (result in odour and sewer corrosion), fluoride.

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