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Water pollution by industrial effluents in India: Discharge scenarios and case for participatory ecosystem specific local regulation

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Abstract

Around the world as countries are struggling to arrive at an effective regulatory regime to control the discharge of industrial effluents into their ecosystems, Indian economy holds a double edged sword of economic growth and ecosystem collapse. This situation if mishandled can cause irreparable ecological harm in the long term well masked by short term economic prosperity. Considering that Industries comply with environmental regulations based on the level of enforcement and their ability to spend for waste treatment, this paper endeavours to sketch probable industrial effluent discharge scenarios under various market-enforcement conditions and proposes possible strategies for effective regulatory regime in India. The authors point out that as India moves towards stricter regulation of industrial effluents to control water pollution greater efforts are required to reduce the risk to public health as toxic pollutants which are mainly colourless and odourless can be expected to be released into the ecosystems. Examples of emerging cases like Tiruppur and Plachimada are presented to assert that ecosystem specific discharge standards is the solution and local communities are ready to participate in environmental decision making to safeguard their resources.

1. Introduction

The growing ecosystem degradation around the world is particularly more damaging to the vast population of poor in the developing countries who depend solely on ecosystem services, and are sometimes the principal factor causing poverty and social conflict [1]. Polluting Industrial discharges—wastewater—is one of the main causes of irreversible ecosystem degradation. Finally it is accepted that the logical basis for setting the limits to discharge of pollutants into an ecosystem—river, wetlands, and estuary—is the carrying capacity i.e., the amount of an individual pollutant that can be safely assimilated by that specific ecosystem. Hence regulators of industrial pollution are moving towards a carrying capacity based regime which will decide the limits—discharge standards—that can be let into a specific ecosystem through programs such as total maximum daily load[1] (TMDL) in US [2] and integrated pollution prevention and control (IPPC) in EU [3].

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[1]A total maximum daily load (TMDL) is a calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources.

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But developing countries like India are yet to progress from the Uniform Discharge standards enforced through centralised command and control (CAC) policy towards a localised carrying capacity based regulatory policy. Out of the three main sources of water pollution such as industrial effluents, domestic/municipal sewage and non-point agricultural runoff, this paper deals with the issues involved in carrying capacity based regulation of industrial effluents in India. This paper is the outcome of analysis of various published reports, articles and most importantly the first author's interactions with the industrial ecosystems of varied scale and sector as an environmental consultant from 1998 till date. The paper is organised as follows: Section 2 reviews the present regulatory structure for water quality management, Section 3 analyses the regulatory structure specifically for Industrial effluent control in terms of legislation, background and validity of discharge standards and reasons for its failure to control pollution of water resources, Section 4 sketches the probable future scenarios of industrial effluent discharge behaviour under various market-enforcement conditions to bring out the implications for public health and presents the case for community led enforcement through ecosystem specific industrial effluent discharge standards.

2. Water quality management policy in India

Countries around the world have framed their water quality policy to work in the following manner:

- Frame legislation and form institutions to deal with water pollution.
- Institutions frame acceptable standards of water quality and assess surface and ground water quality around the country through monitoring.
- Design strategies to attain acceptable water quality by setting and enforcing limits for specific categories of pollutant discharges from industrial, municipal and other sources.

In India components of the above mentioned process are carried out without the required correlation between them, hence the Central Pollution Control Board (CPCB) Monitors water quality around the country and sets uniform discharge standards minimum acceptable standards (MINAS) [4] for industrial and Municipal Discharges to be enforced by State Pollution Control Boards (SPCBs) unrelated to the water quality observed in various locations.

2.1. Water pollution legislation and institutions

The main legislations that are relevant to water pollution are the Water (prevention and control of pollution) Act, 1974, the Water (prevention and control of pollution) Cess Act, 1977 and the Environment (protection) Act (1986) [5]. The CPCB has oversight powers over the various SPCBs. It sets emission/discharge standards, and lays down ambient standards. The CPCB also conducts nation wide surveys about the status of pollution, and of pollution mitigation. The implementation of the national environmental laws and the enforcement of the standards set by the CPCB are decentralized at the level of each state, with the SPCB in charge of this role.

2.2. Regulatory standards for protection of water quality

The ambient water quality in India i.e. the quality of water found in rivers, lakes and groundwater is governed by the ambient standards for water quality which designates the water quality as Classes A, B and C [6] as per the level of various water quality parameters. For control of industrial and municipal discharges the CPCB has issued a set of standards to be enforced by the SPCBs expressed in terms of effluent concentration and are called MINAS [4].

2.3. Monitoring of water quality

In the Inland water quality monitoring programme of CPCB, measurements are made of basic parameters only (Such as pH, bio-chemical oxygen demand (BOD), dissolved oxygen (DO), temperature, chemical oxygen demand (COD), nitrite, nitrate, ammonical nitrogen, total and faecal coli form). There is an urgent need to upgrade it closer to the levels of developed countries such as US, where States are required to prepare a water quality inventory every two years to document the status of water bodies and also identify all surface waters adversely affected by toxic (65 classes of compounds), conventional (such as BOD, total suspended solids, faecal coli form, and oil and grease), and non-conventional (such as ammonia, chlorine, and iron) pollutants from both point and non-point sources [7]. Of course, the above point has to be considered in the context of extreme difference in the availability of funds directly attributable to the economic strength of the respective countries, but it is indicated to illustrate the gap which India has to close in the near future.

Further, monitoring is conducted by CPCB at 870 stations under global environment monitoring system (GEMS) and Monitoring of Indian National Aquatic Resources (MINARS) programmes [8,9]. Again there is an urgent need to increase number of monitoring stations currently at 870 for the whole of India (1/3780 km^2) to levels found in developed nations for effective monitoring. For example to the levels of 386 found in the state of Arkansas in US (1/356 km^2) [10]. Also, there is no mention anywhere regarding monitoring marine ecosystems into which numerous industries are dumping their toxic effluents regardless of the effect it will have on the food chain. However a positive step was taken when Ministry of Environment and Forests (MoEF) constituted the "Water Quality Assessment Authority (WQAA)" in 2001 [11]. Even though the WQAA has not performed to its potential as co-operative effort in monitoring water quality by various agencies [9], the water quality situation is fast evolving which requires a much faster response from it. However for effective regulation, it is felt that the time has come to devolve the responsibility to the states and further down to local Councils like Panchayats, the advantages of which are further discussed in Section 4.

2.4. Status of water quality in India

The performance of the entire water quality policy can be gauged by the status of water quality around India. The results of water quality monitoring carried out by CPCB particularly for the parameter BOD [9]—an indication of organic pollution—for the period 1994–2004 is given in Fig. 1. From the figure it can be observed that the percentage of sampling stations showing improvement are mainly of stations moving from acceptable (Category-C) to desirable quality (Category-B). This can be attributed to implementation of

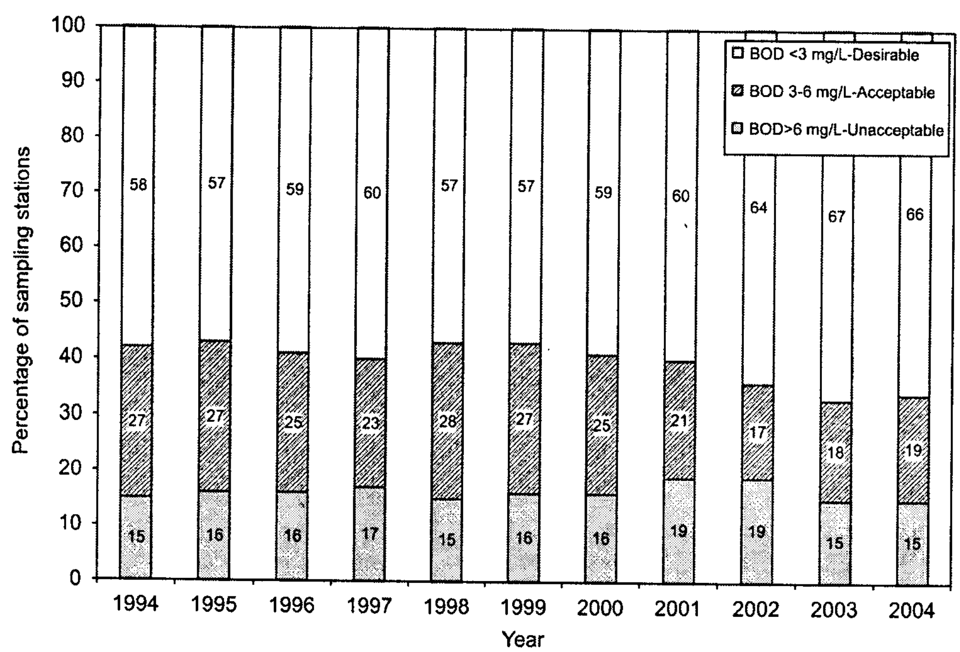

Fig. 1. Trend of biochemical oxygen demand (BOD) 1994–2004.

Table 1
Adequacy of regulatory framework to control water pollution

Sr. no.	Polluting sources	Effect on Ecosystem	Specific standards	Current status
1	Domestic Sewage from towns and cities	Organic pollution of rivers, eutrophication of lakes, spread of water borne diseases	MINAS	Out of 26500 mld of sewage from Class I cities and Class-II towns treatment capacity exists only for about 7000 mld (26%). Out of 271 STPs inspected by CPCB only 150 (55%) were complying with MINAS [9]
2	Industrial effluents (point discharges)	Organic and inorganic pollution, toxic chemicals in food chain	MINAS (industry specific)	No comprehensive statistics on compliance exists as it is dealt mainly by SPCBs. Widespread damage of ecosystem around industrial areas is well documented as shown in Table 2
3	Industrial and mines runoff	Organic and inorganic pollution, toxic chemicals in food chain	No standards/ legislation	No comprehensive study as stored hazardous waste, mine spoils, etc. contribute large quantum of contaminants which pollute surface and ground water
4	Agricultural runoff	Fertilizers leading to eutrophication. pesticides in the food chain	No standards/ legislation	Nation wide studies have not been conducted, apart from regular news articles on pesticides in water and food items

sewerage networks in many cities and better performance of sewage treatment plants (STPs). The worrying aspect of the trend is the unchanging percentage (15%, around 93 rivers and tributaries and most at multiple locations) of sampling stations exhibiting BOD $>$ 6 mg/L (unacceptable), which might either mean that the discharge sources are not complying with the standards or even after their compliance their high quantum of discharge contributes to elevated levels of contaminants. However, the status of water quality cannot be adequately assessed through monitoring of basic parameters in the current inadequate number of sampling stations (for example River Cooum and River Adyar in Chennai which have been converted into virtual sewage drains does not figure in the sampling program). But is the current regulatory framework—legislation, discharge standards, reporting of results—adequate to address all sources responsible for water pollution. The assessment of adequacy is summarized in Table 1.

From Table 1, it can be observed that even though domestic sewage is adequately covered by legislation it continues to be the countrywide source of water pollution mainly due to inability of local bodies to find funds for the huge initial investment required for sewerage systems and STP. Even if the STPs are put up through external funding, proper operation remains a problem as it requires skilled personnel trained in the aspects of biological waste treatment. A prime example is the Ganga Action Plan (GAP), which is yet to yield desired results even after priority attention and funding. The second source of Industrial effluents is the main theme of this paper where the validity of existing standards and issues in enforcement is discussed in detail in Section 3. The last two sources involving area wide discharges—runoff—from industry and agriculture need immediate attention to control the flow of contaminants into the waters—and into the food chain—for a comprehensive water quality regulation in future.

3. Regulation of industrial effluents

3.1. Industrial growth trend in India

Currently, India is considered to be one of attractive destinations for investment in the world economy. Apart from its large domestic consumer base of one billion, it also offers a perfect setting for basing manufacturing and other services to serve the global market owing to its cheap labor [15]. With the Indian Government making an all out effort to increase Foreign direct investment to USD 50 billion within 5 years [16], huge investments can also be expected in manufacturing chemicals, pesticides, textiles and every imaginable product; increase in waste output and spread of toxic hotspots across the country. With the country already losing around 10% of its GDP due to environmental damage [17]; the future portends swift

Table 2
Partial list of locations across india polluted by industrial effluents (*source*—compiled from [12–14])

No.	Type of industry/location	Environmental impact (indicative)
1	Chemicals (dyes, paints, fertilizers, etc.)/ Ankleshwar, Gujarat State	Amla khadi (a rivulet flowing through the industrial estate) in Ankleshwar carries extremely toxic, often acidic, dark brown or black effluents around the year
2	Foundry/Howrah, West Bengal State	Air heavily polluted by particulate matter, water contaminated by heavy metals viz. lead, cadmium, chromium, iron, manganese and lead. Pollution affecting potentially about 1 million in Howrah City and 4 million in Howrah District
3	Tannery/Kanpur, Uttar Pradesh State	Pollutants from the tanneries have led to contamination of Kanpur's groundwater. Toxic elements including hexavalent chromium, arsenic, cadmium, zinc, mercury, nickel, copper and cobalt have found their way into the water supply of Kanpur
4	Chemicals (organic and inorganic, dyes and pharmaceuticals.)/Nandesari, Gujarat State	Higher than normal rate of skin allergies, breathing and circulatory disorders, kidney problems, gastrointestinal disease, chronic stomach problems and diarrhoea have been noted among communities living along the Mahi River contaminated by industrial effluents. Due to soil and groundwater contamination, both crop quantity and quality has declined tremendously, contributing to poverty in the region, and forcing the local population to rely more heavily on industry for economic subsistence
5	Chemicals/Panipat, Haryana State	The concentration of mercury in the sample taken from a tubewell near an industrial area in Panipat was 0.2683 mg/L, more than 268 times the permissible limit of 0.001 mg/L set by the World Health Organisation for drinking water, according to non-governmental organization, Centre for Science and Environment
6	Mainly Tanneries & Textile dyeing/Palar River Basin, Tamil Nadu, India	According to a study sponsored by the Asian Development Bank, pollution loads in the Palar river is extremely high: Total suspended solids: 29,938 kg/day, total dissolved solids: 400,302 kg/day; Chloride: 101,434 kg/day, Sulphide: 3818 kg/day; BOD: 23,496 kg/day; COD: 70,990 kg/day: total chromium: 474 kg/day and cyanide: 22 kg/day
7	Chemicals/Vapi, Gujarat, India	Sediment and effluent in a channel bypassing the common effluent treatment plant and flowing into the river is heavily contaminated with cadmium, chromium, copper, lead, mercury, nickel, and zinc. Greenpeace declared Vapi a Global Toxic Hotspot in 1999

economic growth in the short term with irreversible long term consequences to ecosystems if environmental regulation is not tightened. The scale of the problem expected will be better understood in the light of the pollution haven hypothesis[2] (PHH) [18]. Although results of PHH have been mixed, there is a possibility that India might well become one if the regulatory scenario does keep pace.

3.2. Regulating industrial effluents–enforcing discharge standards

The first serious step towards regulating Industrial discharges was initiated in India with a program in 1993–1994 to identify polluting industries along the rivers for priority action [19]. A list of grossly polluting industries (GPI) (industries discharging 100 kg day or more of BOD) amounting to 851 industries without adequate Effluent Treatment Plants (ETP) got identified and were ordered to install ETPs within 3 months or face closure. The result of this program was claimed as a huge success and as of August 2003 it was reported

[2]PHH predicts that as rich developed countries tighten their grip on environmental pollution it becomes increasingly attractive to move the manufacturing of dirty products like pesticides and chemicals to pollution havens where regulation is lax and economic investment is welcomed due to prevailing poverty.

that all but 5 industrial units had installed adequate ETPs [19]. The latest statistics in the above enforcement program lists 139 defaulting units, 235 units closed, and 1927 as having complied out of a total of 2301 medium and large units [20]. Though this action is commendable, it needs to be realised that mere installation of ETP in medium and large units without regular monitoring and lax control over millions of small scale units does not guarantee clean discharges as evident from surface and ground water contamination around industrial areas [21,22]. Further, as Curmally [23] reports, the command and control approach adopted in India is ineffective as they do not meet the criteria of having large infrastructure facilities like laboratories for testing of samples, a thorough understanding of environmental problems, and good monitoring and enforcement capabilities. It is a well documented fact that MoEF and the SPCBs are constrained in terms of their lack of funds and manpower, low morale, political interference and extensive corruption [23–28]. Due to the failure of regulatory authority, public interest litigations in the Supreme Court of India have become the popular tool for pollution problems. During the last decade, the Supreme Court has been involved several times in large scale environment related cases [29,30]. Let us presume that monitoring and enforcement improves vastly in future, in that event are the present discharge standards (MINAS)—which will be enforced—themselves capable of achieving the desired results?

Table 3
Comparison of discharge standards of CPCB (India) and USEPA for integrated oil refineries

Sl. no.	Parameter	CPCB [31]					USEPA Discharge standards based on BPT [32]	
		Existing standards		Proposed standards 2006				
		limit in mg/L	kg/1000 ton crude	limit in mg/L	kg/1000 ton of crude	Sampling method—averaging period	Max for any one day (kg/1000 ton of feedstock)[a]	Average for 30 consecutive days
1	pH	6.0–8.5	–	6.0–8.5	–	Grab 24 h[b]	NS	NS
2	Oil and Grease	10	7	5	2	-do-	21.375	11.375
3	BOD-3 days, 27 °C	15	10.5	15	6.00	Composite 24 h[c]	68	36.125[f]
4	COD	NS	NS	125.00	50.00	-do-	485	247.5
5	SS	20	14	20.00	8.00	-do-		
6	Phenols	1	0.7	0.35	0.14	-do-	0.50	0.24
7	Sulphides	0.5	0.35	0.50	0.20	-do-	0.4375	0.1975
8	CN	NS	NS	0.20	0.08	-do-	NS	NS
9	Ammonia as N	NS	NS	15	6	Composite–monthly[d]	29.25	13.25
10	TKN	NS	NS	40	16	-do-	NS	NS
11	P	NS	NS	3	1.2	-do-	NS	NS
12	Cr (VI)	NS	NS	0.1	0.04	-do-	0.085	0.04
13	Total Cr	NS	NS	2	0.8	-do-	1.025	0.6
14	Pb	NS	NS	0.1	0.04	-do-	NS	NS
15	Hg	NS	NS	0.01	0.004	-do-	NS	NS
16	Zn	NS	NS	5	2	-do-	NS	NS
17	Ni	NS	NS	1	0.4	-do-	NS	NS
18	Cu	NS	NS	1	0.4	-do-	NS	NS
19	V	NS	NS	0.2	0.8	-do-	NS	NS
20	Benzene	NS	NS	0.1	0.04	Grab–monthly[e]	NS	NS
21	Benzo(a) pyrene	NS	NS	0.2	0.08	-do-	NS	NS

[a]Converted from original unit of kg/1000 m^3 of feedstock considering 800 kg/m^3 of oil. NS—not specified.
[b]Parameters to be monitored daily: grab samples for each shift with 8 h interval.
[c]Parameters to be monitored daily: composite sample (with 8 h interval) for 24 h flow weighted average.
[d]Parameters to monitored once in a month: composite sample (with 8 interval) for 24 h flow weighted average.
[e]Parameters to monitored once in a month: grab samples for each shift with 8 h interval.
[f]BOD-5 days 20 °C.

3.3. Discharge standards in India—validity

The discharge standards in place which were framed during the late 1980s and early 1990s, barring a few exceptions have remained the same ever since regardless of the state of the environment or the effluent treatment technology. However, in some cases such as Standards for Petroleum refineries which is the latest from CPCB [31], it is even better than that of Environmental Protection Agency of US (USEPA) based on best practicable control technology currently available (BPT) [32] as shown in Table 3. At a time when USEPA has moved from discharge limits for point sources to TMDL based regulation [2], a similar policy initiative by MoEF is yet to be initiated. However as evident from Table 3, the CPCB has to be appreciated for showing an improvement in setting the standards for petroleum refineries which is even better than USEPA standards based on BPT. But the point to be understood is that whereas USEPA standards require adherence over an averaging period of 30 days which is quite logical considering the inherent fluctuations on day to day operations of a refinery, the CPCB standards risk being overambitious in opting for stricter limits and a 24 h averaging period. However, considering that such standards can only be set for an industry like the refineries which can pass on the cost to the consumers, the challenging aspect will be of revising the standards for other industries to reach the comprehensive nature as that of USEPA. The future focus has to be to move on to local discharge standards based on the ecological carrying capacity of that specific ecosystem.

4. Industrial effluent discharge scenarios under various enforcement-market conditions and strategies for regulation

In the preceding sections, having established that the current status of water quality management needs improvement to handle the current situation more effectively, it can be understood that any attempt at improvement should also be equipped to deal with all possible effluent discharge scenarios. The probable discharge scenarios which can be expected to arise under various market (economic situation of the

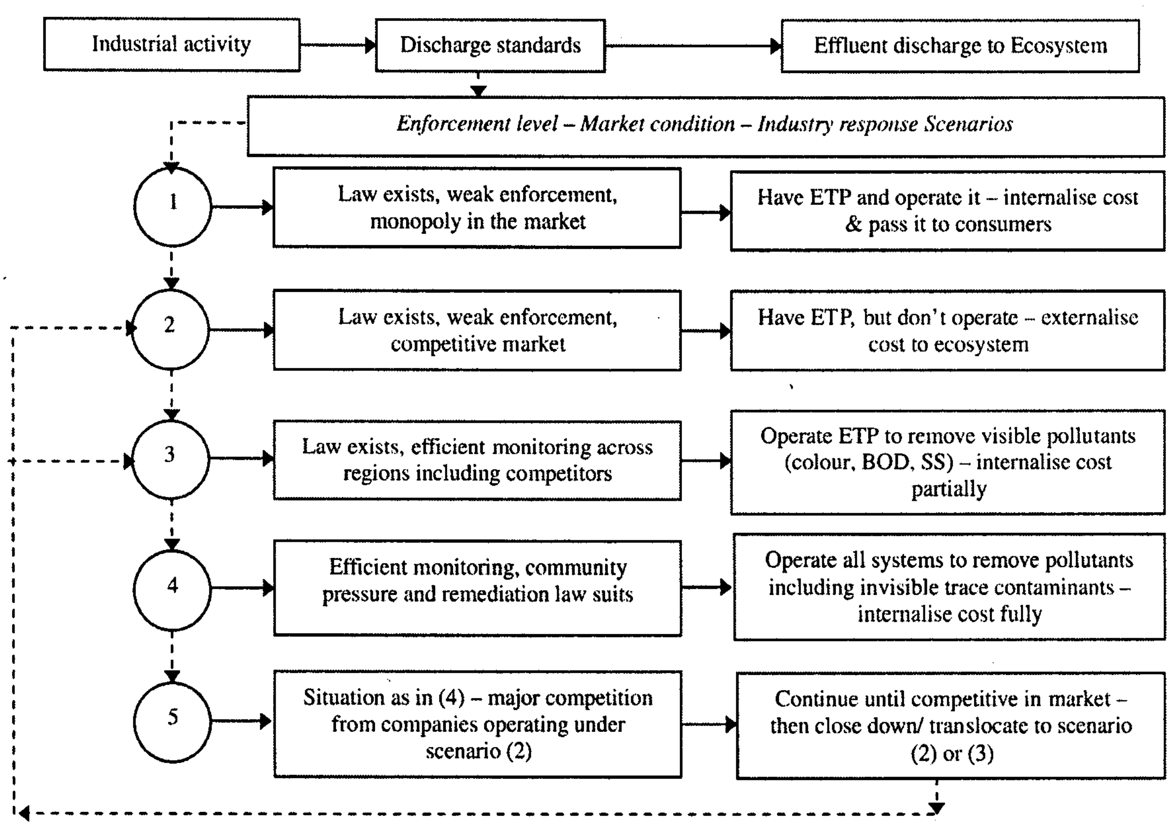

Fig. 2. Industrial discharge scenarios under various enforcement-market conditions.

industry)-enforcement (level of monitoring and enforcement by regulators) conditions are presented in Fig. 2. These scenarios are outlined purely to point out the implications of character of discharges which can be expected and initiatives required to deal with them. The widely observed basis on which these scenarios are grounded is that, when faced with economic pressure firms tend to externalise the cost wherever possible, cutting down on waste treatment in this case. This is possible only when aided by the enforcement level i.e. when it is weak. Alternatively, they will adhere to the discharge standards when faced with regulatory pressure, but only at the risk of stiff competition from firms based in pollution havens. The major implications of these scenarios lie in the nature and level of contaminants that can be expected to be discharged and efforts needed to counter them. The nature of effluents, ease of identification and risk to natural ecosystems under different scenarios are summarised in Table 4.

It is quite logical to state that it is not possible to classify the current Indian situation as a whole under any one scenario as given the complex nature of the market dynamics it is probable to identify areas/industry sectors under more than one scenario. However, the ecosystems near heavily industrialised areas can be said to operate in Scenario 2. Ironically the advantage of Scenario 2 as shown in Table 4 is that since the river and stream pollution is visible through the colour and odour, the communities do not use it for drinking and look for alternate sources. But in Scenario 3 when enforcement improves to the extent of controlling conventional pollutants and not the toxic pollutants most of which are colourless and odourless, the streams and rivers onto which the industries discharge their effluents look deceptively clean. Here lies the real danger of the communities using it for drinking and other activities—either directly or through municipal water supply—and getting exposed to toxics. Hence as enforcement moves from one scenario to the next greater efforts are needed to reduce the risk from toxic chemicals and finally move onto Scenario 4 where a concerted effort from the regulators and the community is required. However the difficult part is staying in Scenario 4, as the firm's competitive edge will be lost if industries operating under Scenario 2 (pollution havens either national or international) enter their market. Under this circumstance the firms may either close down, or relocate to Scenario 2 through investment in pollution havens or might be allowed to operate with lenient regulation.

Table 4
Nature of effluent and implications under various discharge scenarios

Scenario	Nature of effluent	Ease of identification of contaminants	Cost of enforcement	Ecosystem damage potential	Risk to public health
1	Generally clean, but due to weak enforcement possibility of colourless effluent with invisible toxic pollutants i.e. heavy metals, pesticides, etc.	Difficult and expensive. Requires sophisticated equipments like atomic adsorption spectroscopy, gas chromatography, etc.	Low—as industry compliance will be high	High—long term	High—Long term through chronic ailments
2	Highly coloured effluents with all possible contaminants	Easy to identify basic parameters	Low—as enforcement is weak	High—Short and long term	Low—short term as public will avoid usage due to visible quality
3	Colourless, with invisible toxic pollutants i.e. heavy metals, pesticides, etc.	Same as Scenario-1	High—requires extensive funding for manpower and infrastructure	High—long term	High—long term through chronic ailments
4	Colourless, with negligible toxic pollutants i.e. heavy metals, pesticides, etc.	Same as Scenario-1	Very high—apart from technical expenditure, legal expenses will go up	Low	Low
5	Will be fluctuating between scenarios 2–4	Will be varying between scenarios 2–4	High—will involve difficult decisions between closures and loss of jobs	High—Short and long term	High—Short and long term

Hence for successful environmental regulation in a country, it can be said that effective regulation across the country, market competitiveness through R&D and innovativeness of the industry to adopt low waste technologies also play a major role. From the above scenarios it can be deduced that to protect the ecosystems from toxic industrial effluents the following initiatives involving two main components are important:

Eco-centric component:

- carrying capacity based discharge standards which are set as per the local ecosystem
- effective monitoring programs to really deter industries from compromising on effluent treatment

Econo-centric component:

- encouraging industries to reduce toxic discharges through incentives and subsidies
- Aiding industries to move towards low waste technologies through investment in R&D, technology transfer from developed countries and encouraging industrial symbiosis.

4.1. Future strategies for regulating industrial discharges in India

Some of the initiatives identified in the previous section are already in place albeit yet to make an impact on the regulatory situation. The initiatives which are currently in place along with suggested additional measures are summarised in Table 5.

4.1.1. Why environmental regulation has to be ecosystem specific and local?

The important aspect of regulation of industrial discharges will be best accomplished with the help of local bodies, as management of ecosystems unlike economics has to be at the local ecosystem level only—where the dynamic nature of impact of effluents can be appreciated only by those who are affected by it on a daily basis—and cannot be centralised. Further, the positive role of public participation in environmental management is now well acknowledged [33,34] and co-management of resources with the local community involvement in problem solving and decision making is advocated widely as the path towards sustainable management [35]. Regulation of industrial pollution through local governing councils is an integral part of regulatory regime in many countries like LA-IPPC in UK [36] and Japan [37], but destroyed in India due to the centralized governance introduced by the British. Recently, there has been considerable devolution of power in India to the Village Panchayats (local councils) through the 73rd amendment Act, 1992 [38] and in

Table 5
Current Initiatives and additional efforts suggested to regulate Industrial effluents

Sr. No	Type of industry/ location	Enforcement problems identified	Current initiatives in place	Additional efforts suggested
1	Large industries	Most of them operating under Scenario–3, no control over release of toxics	MINAS standards, EIA[a] notification	Ecosystem specific standards, monitoring through local institutions. Involving local public in EIA. Linking EIA into land use planning. Monitoring of sediments & food chain is required to assess impact of toxic contaminants
2	Small and Medium Enterprises (SMEs) concentrated in Industrial estates	Most of them operating in Scenario-2	CETPs[b] in Industrial estates, lenient regulations both in EIA and MINAS. Waste minimisation circles	Ecosystem specific standards, monitoring through local institutions. Declaration of critical areas, charge based operation of CETPs for treatment and compensation for ecosystem damage. Linking EIA into land use planning

[a]Environmental impact assessment [5].
[b]Common effluent treatment plants [20].

many areas they have started playing a significant role in environmental decision making [39,40]. The key aspect of protecting environmental resources is the assignment of property rights—in this case to the local councils—to facilitate its protection from industrial externality i.e., discharge of waste in the absence of property rights. The first step is to work out the ecosystem specific standards i.e., akin to the TMDL program of USEPA [2].

4.1.1.1. Regulation by the community: the case of plachimada vs coca-cola. It is a widespread tendency on part of the ruling elite, i.e., the bureaucracy, politicians, academics, researchers, etc, to raise questions like: how will the village panchayats be able to deal with complex issues like regulation/management of resources? Is it not the role of the Government to frame policy measures aided by researchers who are divorced from ground realities? The community of Plachimada seems to belie our conception by exercising its powers to protect its resources from pollution and exploitation. To summarise for the sake of brevity, Perumatty Grama Panchayat vs. M/s Hindustan Coca Cola P. Ltd. & Ors. is the case which is pending in Supreme Court involving a panchayat which has cancelled the operating license of an MNC for damaging its ecosystem through pollution from its toxic discharges and excessive withdrawal of ground water, for details refer [41]. The list of proactive panchayats are growing—Eloor Gram Panchayat, Kerala; Cuddalore Panchayat Union, Tamil Nadu—and now it is more a question of whether India is going to move into a participatory model of governance for a sustainable future or is it still going to cling to the power model, where decisions are made by an elite minority leading to growing conflict.

Any regulatory programme—MINAS, Ecosystem specific Standards—will be successful only through effective monitoring. To achieve this the local council of the areas affected by these effluent discharges can be empowered to collect samples randomly at a frequency based on the toxicity of effluents and shall send it for analysis preferably to a district level accredited laboratory or public funded academic/research institutions—where sophisticated equipments are already in place—with the local SPCB providing it a supporting technical role. The impact of information availability in the hands of local community is projected to be the key factor in cost effective regulation of pollution in the coming years [42]. The cost of these regulatory exercises will be justified when we compare it against the 10% of GDP (approx. USD 50 billion) India is estimated to be losing due to environmental degradation [17].

The main advantage in involving the local people with a sense of ownership is that a major portion of manpower cost can be saved, since they will not hesitate volunteering to safeguard their own survival. Slowly, the local councils can be aided to upgrade their programmes to address domestic sewage treatment, non-point sources of pollution (fertilizer, pesticide run-off from farms) and finally total environmental management for sustainable development. The emphasis should be to utilise existing institutions (academic/research) in every taluk (*subdivision of a district*) and district. A key institute should be accorded honorary status as a nature node which shall function as the nodal agency responsible for collating technical knowledge regarding best practices in environmental management relevant to their local ecosystem (example—coastal, delta, wetlands, forests, etc.). The key institute need not spend much of its resources for this endeavour as it only needs to collate information available through the web already being actively produced by the ENVIS centres [43], MoEF, CPCB, SPCBs and numerous institutions around the world.

4.1.2. Emerging ecosystem specific regulation in India—Tiruppur and others

Even before any initiative by the regulators to move towards ecosystem specific standards, cases forced towards such regimes have started merging in India. In Tiruppur, faced with continuous polluting discharges from textile industry the farmers got themselves organized and resorted to agitations and legal recourse demanding the judiciary to rectify the situation brought on by the failure of the regulators. The judiciary promptly pulled up the SSIs for not heeding their earlier directions and ordered them to pay up the subscription fees for putting up a joint zero discharge effluent treatment plant within a deadline or face closure [30]. The loss of ecology commission, a State Government Agency, has asked the Tiruppur dyes union to pay INR 4 crores (USD 0.83 million) of compensation a figure contested by the farmers union as it works out to a meagre INR 240/ha [44]. The case of Tiruppur is an example, where faced with widespread damage to agriculture from textile effluents, the judiciary in the face of inaction by the regulators has forced the industry to move on to zero discharge technology [30], which is even stricter than TMDL which would have allowed some amount of effluent discharge.

The case of Taj trapezium [45] is another example although it is concerned with air emissions, in the setting of location specific air quality emission standards i.e., ecosystem specific. The eco-sensitive zone notification under EPA 1986, which restricts/prohibits industrial activity in ten specific areas [5] is another example where the regulator has gone in for ad hoc notifications—are there only ten eco-sensitive areas in India worth conserving?—instead of initiating comprehensive measures for a country wide ecosystem specific regulatory notification. Hence it is imperative that efforts are directed to achieve this key requirement.

4.1.3. Other important initiatives required for comprehensive regulation

4.1.3.1. Strengthening of MoEF– CPCB. The need of the hour is to strengthen the MoEF–CPCB in terms of multi-disciplinary organisation capable of effective performance, which at present is unable to undertake with its existing human resources and infrastructure. Rather than trying to follow in the footsteps of developed nations whose levels of resource consumption India will never and does not need to attain, it has to devolve decision making to local communities and reawaken the sustainable traditional system of resource conservation.

4.1.3.2. Regulation of large industries through economic instruments. For a large industry operating in a rural setting, the economic instrument of coasian bargaining [46] is an effective option. The industry can negotiate with a local council for its discharges and compensations to arrive at a consensus, as it is evolving in the case of Plachimada [41]. The role of the agencies like SPCB/MoEF will be to provide technical assistance to the local council in protecting their interests and to aid the industry in integrated pollution prevention control (IPPC) efforts which are accepted to be a better approach than end-of-pipe treatment technologies. Further, the same industry can be controlled by the SPCB/ MoEF with economic instruments such as pollution taxes, incentives, etc. [46]. The immediate steps to implement the above will be to build capacity in local institutions for their effective role.

4.1.3.3. Regulation of small and medium enterprises (SMEs). The difficult aspect of regulating the SMEs needs to be tackled in a different way. The first requirement is to locate them in clusters/industrial estates based on industrial symbiosis and carrying capacity [47]. With most of the SPCBs still clueless regarding the actual number of SMEs, control of these will remain a challenge as they are providers of employment to the vast unskilled labour force in India and have little or no capital to spend on pollution control [24,48,49]. The only way out in industrial estates is not only to route the effluent of SMEs to a CETP—as it is rightly done currently—but also to ensure that it functions efficiently through efficient monitoring and heavy penalties to compensate the victims i.e., mainly farmers affected by it. Further, one has to bear in mind that a CETP merely concentrates the contaminants into a solid form i.e., sludge from the clarifiers. The threat of water contamination is fully averted only when this toxic sludge is properly disposed in a secured landfill.

4.1.3.4. Declaration of critical zones under no win situation. In areas of heavy ecosystem damage around industrial areas, continuing conflict regarding compensation between the industries unable to afford pollution control measures and communities unable to continue their livelihoods is a no win situation (industrial areas like Vapi, Ankleshwar, Cuddalore, etc.). Areas of heavy damage where remediation is uneconomical and not possible in the short term, should be declared as pollution hotspots/critical zones and the affected population must be resettled/rehabilitated. Let the industries continue and concentrate on economic growth and shall be made to adopt IPPC regulation based on long term—5–10 years—binding targets. Where resettlement is not possible, legislation should be framed which will hold the industries responsible to provide livelihood allowance, medical facilities, health insurance and licence fees for local resources (land, water and air). A policy to compensate people affected by industrial pollution—and not merely accidental release of hazardous substances as dealt by The Public Liability Insurance Act, 1991 [5]—is a significant need. Without such a policy, India could end up doing more damage to its people and ecosystems while serving the world.

4.1.4. *Traditional knowledge and sustainable development—the low growth alternative*

Regarding the environmental Kuznet's curve (EKC) [17], it can be said that developing countries cannot wait for environmental turnaround to happen at high income levels. As Pachauri [17] states 'A developing country like India cannot pursue the same path, and would need to set up a governance structure and policy regime that allow the turning point to take place at substantially lower levels of income'. Controlling effluent discharges is just one aspect on the path towards sustainable development. Since it is impossible to elevate everybody in a country like India to consumption levels prevalent in developed countries, it is time to decide the level of industrialisation that will be in harmony with goals of sustainable development (for detailed discussion refer [50]) and understand that mechanistic science cannot solve all problems originating from exploitation of nature [51,52]. Hence for sustainable development countries have to look inward to their own people as noted by an eminent Indian environmentalist Anil Agarwal "The person who knows most about the village ecosystem is not a Harvard, MIT, Cambridge or even Delhi University professor, but the villager himself" [53].

5. Conclusions—the challenges ahead

The current regulatory system in India for control of industrial discharges needs a complete improvement in terms of standards setting, monitoring and enforcement. As the industrial discharge behaviour fluctuates between various scenarios outlined in this paper, the monitoring system for water quality needs to be strengthened both in terms of parameters monitored, water resources coverage and timely reporting to public domain. The time has come to move towards ecosystem specific discharge standards to maintain the health and productivity of natural resources on which the majority of Indians are dependent. But as pointed out, any regulation will be effective only if it has a strong monitoring component. Here the right way forward will be to empower the local communities to ensure their right to a healthy environment and ultimately their survival. Of course, there are a lot of questions for which we need to find answers such as: Will the industry be able to survive by spending on waste treatment? What about the unemployment that will be created through closure of defaulting units? Is economic growth rate the only solution to millions still below the poverty line?

Managing ecosystems is an adaptive process where considering our limited understanding of dynamic natural processes, there are no correct answers at the beginning, and we have only correct directions. Environmental management in India which is closely linked to poverty alleviation cannot be pursued without considering alternative development strategies apart from industrial growth. Limits to industrial discharges will be ineffective without corresponding limits on resource consumption and policies to achieve intra-generational equity. The aspect of monitoring and enforcement by local community has its initial constraints in terms of technical competency, infrastructure and ability to face industrial pressure. But as an inclusive participatory approach which gives them a stake in the decisions which affect their survival, communities need the opportunity and time to learn and evolve and ultimately to ensure their sustainability.

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