Population and natural resources: A case study of Yamuna water pollution

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This study examines linkages between environmental degradation (specifically water pollution) and population within India. The hypothesis postulated is that the link between population and environmental degradation is mediated by the nature of institutional intervention in place. This hypothesis is examined with the help of two alternative methodologies. Firstly, a multiple regression using data for 9 districts, through which River Yamuna flows and secondly, using a simultaneous equation modelling. Both the methodologies illustrate, population growth does not always leads to environmental degradation, if literacy rates are improving and new technologies are being invented. Although degradation might continue to occur, in such a scenario if there are governance issues and hence institutional failure.

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1. Introduction

There is much convincing evidence that the rate at which we currently exploit our natural capital (aquifers, ocean fisheries, tropical forests, etc.) have a very high probability of changing its characteristics, and dramatically for the worse with little or no advance notice. Indeed, many ecosystems have already collapsed, with short notice.

In such a disconcerting scenario, the most common culprit as pointed out by economists is institutional failure and the environmental externalities caused by degradation, as very aptly pointed out in by, Cohen de-votes.

The theoretical and contemporary evidence tells us that environmental degradation is a symptom of: institutional failure. The malfunctioning institution could be the market, and the failure could be that of a group of nations unable to agree on any policy. But, the consequences of these malfunctions are, resource allocation failures, borne across generations and contemporaries. One of the consequences of these institutional failures is that, the CPR's have deteriorated in recent years in many parts of the world. There are several underlying reasons: Firstly, from deteriorating external circumstances, under which both the private and communal profitability of investment in the resource base decline. Apart from political

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instability being a visible cause of resource degradation, uncertainty in communal property rights is a greater underlying hidden cause. If the security of a CPR is uncertain, the return expected from collective action is low. The influence would run the other way too, with growing resource scarcity, rival groups battle over resources contributing to political instability. Second reason for the deterioration of CPRs is due to rapid population growth. The latter triggers environmental degradation if institutional practices are unable to adapt to the increased pressure on resources. When institutions governing the CPRs deteriorate, households tend to free-ride on the resource base. As the cost of maintaining a household is passed on to others, the net private benefits of accumulation of more "hands" to mine the CPRs can increase. The third reason being, communal rights have been by central fiat. For example, in order to establish its political authority, a number of states in Sahel imposed rules that destroyed communal management practices in the forests. All the three reasons are a cause as well as result of failure of institutions.

Rivers or water bodies can also be looked at as CPRs or even as open access resources. The reason why it is a bit difficult to conserve this natural resource is because, it is almost impossible to clearly define the property rights of rivers (water bodies), as it is a fugitive resource.

Ecosystems are driven by interlocking non-linear processes that run at different speeds and operate at various spatial scales (Steffen et al., 2004), the reason why it harbours multiple basins of attraction. The global climate system is a well-known example (Bigg, 2003). So, flips in the capacity of ecosystems to supply useful service to us, share three important characteristics:

1. They are frequently irreversible (or at best take a long time to recover).
2. Except in a very limited sense it is not possible to replace degraded ecosystems by new ones.
3. Ecosystems can collapse abruptly without much prior warning (Dasgupta, 2009).

According to the Millennium Ecosystem assessment, the biodiversity of freshwater ecosystems has been degraded more than any other ecosystem, including tropical rainforests (Nema, 2007).

Water pollution is a serious problem in India as almost 70 per cent of its surface water resources are contaminated by biological, toxic, organic, and inorganic pollutants.

In 1995, the Central Pollution Control Board (CPCB) identified severely polluted stretches on 18 major rivers in India. Not surprisingly, a majority of these stretches were found in and around large urban areas. The high incidence of severe contamination near urban areas indicates that the industrial and domestic sectors' contribution to water pollution is much higher than their relative importance implied in the Indian economy (Murty and Markandya, 2011).During 1995-2009,it was observed that the water quality has deteriorated at a much faster pace. The worrying aspect of this trend is the high percentage of sampling stations exhibiting unacceptable levels of pollution, 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 (Rajaram and Das 2008).

Another aspect of water pollution in India is inadequate infrastructure, comprising of monitoring stations and frequency of monitoring for monitoring pollution. Secondly the receiving water bodies also do not have adequate water flow for dilution. Therefore, the oxygen demand is increasing.

Out of the total effluent treatment capacity of 11554 MLD in the country, about 70 per cent (8040 MLD) has been created in 35 metropolitan cities. Metropolitan cities treat about 52 per cent of their wastewater. Delhi and Mumbai account for about 69 per cent of the treatment capacity of metropolitan cities. This indicates that smaller towns and cities have very little wastewater treatment capacity.

In the industrial sector, on the other hand only 59 per cent of the large and medium industries had adequate effluent treatment in 1995.There are 0.32 million small-scale industrial units in India and due to the presence of scale economies in water pollution reduction, it is uneconomical for these units to have ETPs of their own (Murty et al. 1999).These small-scale units contribute almost 40 per cent of the industrial water pollution in India.

We realise, population growth leads to environmental degradation with rising industrialisation and urbanisation. But an increasing population does not always lead deterioration of CPR‟s as explained meticulously in the literature review section, it is institutional failure which explicitly leads to it.

Hence, the aim of this thesis is to study the relation between water quality, population, industrialisation and institutions.

2.Review of the literature

It is widely observed that population pressure contributes to the deterioration and depletion of important natural resources in developing countries. Growing rural populations and rising subsistence demands have resulted in the decline of ecosystems.

According to ecologists, the acute resource scarcities faced in the developing countries today is because people in world’s poorest regions face acute scarcities relative to their numbers that they are so poor. On the contrary, economists believe, people there experience scarcities, because they are poor. A natural response to the former by the latter is that people come first and therefore current poverty should matter the most. However there are two problems with the above made statement. First, future will eventually become the present. Secondly, extreme poverty is frequently associated with a degraded environment.

There is no denying, the EKC (Environmental Kuznets Curve) represents an inverse U shaped link between economic growth and environmental quality. But the part showing the positive link, which elucidates that environmental quality starts improving after the average income of a country reaches a certain point over the course of development, is often ignored by the environmentalists. For e.g. the large scale availability of water and the increased protection of the human race against water borne diseases in industrial countries is a part of the process of economic growth those countries have enjoyed for quite some time. Growth in scientific knowledge ,investment in public infrastructure and universal education in these countries have meant that citizens there, have a far greater knowledge of environmental hazards than their counterparts in poor regions and more importantly, have the resources to avoid them, as higher income leads to a higher demand for environment friendly products (Dasgupta, 2009).

But, in developing countries, the negative part of the link seems to be applicable. The reasons for degradation of water quality, in this case ranging from, the ever increasing population, and industrialisation to institutional failure.

Partha Dasgupta (2009), mentions agricultural land, threshold grounds, grazing fields, village tanks and ponds, woodlands and forests, rivers and streams, mangroves, or coral reefs and the importance of local natural resources base to the rural poor becomes self-evident. The Centre for Science and Environment (C.S.E.,1990) recorded that, of the total number of hours worked by the villagers in a micro watershed in Himalayas,30% of them were involved in cultivation,20% in fodder collection, and about 25% was spread evenly between fuel collection, animal care and grazing. The rural poor are too dependent on the natural environment for their subsistence needs due to the unavailability of alternative sources of livelihood, which leads to over exploitation of the natural resources.

Although, unfortunately, modern growth theories ignore every layer of these resource allocation failures. It is only recently, with the global climate changing and the growing scarcity of fresh water in the world's poorest regions, that mainstream development economists have acknowledged ,that at the scale at which the world economy has been operating for some time, nature is in many aspects fragile.

2.1 Predator-prey model

The predator- prey relation can also be examined in this context. Predator-prey models are the building blocks of the bio and ecosystems as biomasses are grown out of their resource masses.

Species compete, evolve and disperse simply for the purpose of seeking resources to sustain their struggle for their very existence. In this case, they take the form of resource-consumer. They deal with the general loss-win interactions and hence may have applications outside of ecosystems.

When seemingly competitive interactions are carefully examined, they are often in fact some forms of predator-prey interaction in disguise. The Lotka–Volterra system of equations is an example of the predator prey model, which is a more general framework that can model the dynamics of ecological systems with predator-prey interactions, and competition.

The Lotka-Volterra model makes a number of assumptions about the environment and evolution of the predator and prey populations:

1. The prey population finds ample food at all times.

2. The food supply of the predator population depends entirely on the prey populations.

Another way to look at this is, in terms of the historical context. For instance, 20,000 years ago, the ever increasing human population was the prey and nature, the predator. After the peak of the last ice age, melting ice resulted in rising seas, which eventually covered much of the previously available land surface. According to Pfeiffer, human population had been increasing gradually for ages but a land squeeze also began about 20,000 years ago, which reduced a fifth of the total land surface area. So much water "was locked up in polar ice caps and glaciers that ocean levels stood 250 to 500 feet lower than they stand today."(Dasgupta,2009).

And in lieu with the current scenario, the inverse of predator prey relation exists; nature being the prey and the growing population, predator.

However, Chopra and Gulati (1997) denies that population always results in degradation of natural resources. According to them, although it is often postulated that poverty results in rapid rates of natural capital depletion and higher rates of population growth compound the adverse environmental impact, but the analytical argument is „overly simplified‟. It seems plausible to argue that high levels of poverty and population growth constitute increased pressure on natural resources. Since such resources can often not be excluded from use by all groups, increased pressure of demand results in progressive deterioration. Rates of discount of the future are higher at low levels of income as satisfaction of present demand becomes the first priority. The consequent high levels of present demand which far exceed the rate of regeneration result in depletion of the environment.

A number of other factors, in particular institutional structures, both of government and of market origin, are found to be significant contributors to degradation. On a more positive note, some kinds of changes in institutional structure are seen to be playing a useful role. Small communities, often with non-government and/or government support, are seen to come together with the express intention of preserving environmental resources linked with consumption patterns and livelihoods. Such changes in the institutional framework are, in effect, a change in the nature of property rights. One of the outcomes of this change is an increase in the capacity of the environment to support larger populations. Also, in a quest to not let the resources degrade with rising population, it results in invention of newer forms of technology, which prevents population from preying on the natural resources.

Of all the natural resources, water is one of the most essential to sustain human beings. Clean, safe and adequate freshwater is vital not only for the survival of all living organisms but also for the smooth functioning of ecosystems, communities/herds and economies. Both natural processes and human activities affect the quality of surface water. But the major sources of water pollution are from human settlement and industrial activities, both a result of the increasing population.

Water as an environmental resource is regenerative in the sense that it could absorb pollution loads up to certain levels without affecting its quality. In fact there could be a problem of water pollution only if the pollution loads exceed the natural regenerative capacity of a water resource. The control of water pollution is therefore to reduce the pollution loads from anthropogenic activities to the natural regenerative capacity of the resource(Murty and Markandya, 2011).

Since 1994 in India, enormous quantities of polluted water have continued to flow in or around urban settlements. It is also influenced by the problems imparted by industrialization, urbanization and rapid agricultural developments similar to other riverine system. The Third World Centre for Water Management has estimated that less than 10 per cent of wastewater generated in the country is now properly collected, properly treated and then discharged to rivers and lakes in an environmentally safe manner (Report on government of NCT of Delhi, 2005).

One such river is Yamuna, one of the major freshwater sources of India. The total length of Yamuna from its origin near Yamunotri to its confluence with Ganga River at Allahabad is 1376 kilometre and the total basin area of the river accounting to 366223 km sq., which covers part of geographical area in the states of Uttaranchal, Uttar Pradesh, Himachal Pradesh, Haryana, Rajasthan, and Madhya Pradesh & NCT – Delhi. These urban centres draw fresh river water for various activities. In return, almost the entire wastewater generated by these centres is disposed into the river. This is one of the prime reasons for deterioration of Yamuna River water quality from urban agglomeration of Delhi up to Chambal River confluence (CPCB report, November 2006).

About 85% of the total pollution in the river is contributed by domestic sources. The domestic pollution is the major source of pollution in Yamuna River, mainly caused by the urban centres. The intensity of impact of domestic pollution on river therefore depends on the efficiency of the wastewater collection system, type and length of the waste transportation system. If wastewater gets more retention time within urban premises before reaching to receiving water bodies, in such case the pollution load will reduce due to biodegradation and settling. In addition, there are numerous unauthorized colonies which exist in various urban centres. Due to non-availability of sewerage system in these colonies, the night soil is collected, transported and dumped either in drains, tributaries or directly into river without any treatment.

The condition of river deteriorates further due to the abstraction of significant amount of river water (for domestic and irrigation purposes, both amounting to nearly 92 per cent of the river water), leaving almost no fresh water in the river, which is essential to maintain the assimilation capacity of the river.(CPCB report, November 2006)

To keep up with the tide of the times, and prevent further degradation of water quality, the Government of India (GoI) decided to take up water quality restoration measures named as Yamuna Action Plan (YAP) under the mega project of the Ganga Action Plan (GAP) phase– II.

But unfortunately, according to CSE (2009), though many years have passed by, the river is still dirty. One of the causes for the failure of the YAP is, the entire design is based on the wastewater generation from official water supply .It overlooks huge amounts of waste generated from the groundwater extraction in the city. In other words the volumes of wastewater to be intercepted are under estimated. Also, they failed to ensure adherence to the stipulated quality parameters. The report on Government NCT of Delhi,2005 stated, that the sewage shown as treated was not verifiable as the flow meters meant to measure the incoming raw sewage and outgoing treated effluent were either non-functional or non-existent at the plants test checked in audit. Also, the quantum of sewage being depicted as treated at the STPs was based on the design capacity of the pumps with reference to the number of hours it actually ran. Thus, the quantum of sewage being depicted as treated was a normative assessment rather than by actual measurement with proper calibration.

Biswas (2009) further adds on there is a serious indictment of very poor water quality management. In 20 years' time, India's population will be much higher and economic activities will explode. It will be a completely different country in 2030 compared to 2010. Thus, if Yamuna is to have better water quality in the future, planning must consider the likely conditions then and not now. He further says that India must learn from successful river cleaning experiences of other countries.

In spite of institutions being in place due to governance issues the water quality is deteriorating over time with increasing population, making the predator prey model functional in case of River Yamuna. However, we are yet to see whether population can have some positive impacts on decreasing water pollution, with the advent of technology and literacy rates which improves with higher population growth.

A lot of studies have empirically analysed the link between water quality (taken as a measure of environmental degradation), population, industrialisation and institutions. Even though, Goldar and Banerjee (2004) have attempted to assess the impact of informal regulation of water pollution on water quality in Indian rivers and for this purpose, an Ordered Probit Model is estimated for 106 monitoring points on 10 important rivers for five years, 1995-1999. But, none of the studies have so far attempted to study this link using a simultaneous equation modelling (SEM), especially in the case of Yamuna. This study endeavours to do so, for 9 districts on 1 important river, Yamuna for 3 years, 2001, 2006 and 2010.

3.Data description and methodology

To analyse the relation between water quality, institutions, population and industries, two econometric methods have been used, a multiple regression and simultaneous equation model.

CASE I

Firstly we will use a multiple regression model. The model for case I is as follows:

BOD = f (PD, IETP, LR, II)

where,

BOD = Biochemical Oxygen Demand
PD = Population Density
IETP = Investment in effluent/sewage treatment plants
LR = Literacy Rates
II = Number of industrial units

CASE II

The nature and strength of linkages between water quality and institutions can also be studied with the help of Simultaneous Equation System (SEM). A SEM is used here, as the explanatory variable Investment in ETP/STP (IETP) is jointly determined with the dependent variable BOD, typically through the equilibrium mechanism discussed below. Conceptually speaking, we expect an increase in BOD leads to an increase in investment in ETP/STP (as discussed above). Moreover there is ample empirical evidence of reverse causality running from BOD towards investment in ETP/STP. (See, Progress in Water Quality: An Evaluation of the National Investment in Municipal Wastewater Treatment, EPA, June 2000, for example.)

Hence, the endogenous variable BOD can be taken as a function of Investment in ETP/STP (IETP), number of industrial units (II), literacy rates (LR) and technology used in ETP/STP (T):

BOD = f (IETP, II, LR, T)

where,
BOD = Biochemical Oxygen Demand
IETP = Investments in effluent and sewage treatment plants
II = Number of industrial units
LR = Literacy Rates
T = Technology

The endogenous variable Investment in ETP/STP(IETP), on the other hand can be taken as a function of Population density(PD), Technology and BOD(Biochemical oxygen demand) :

IETP = f (PD,T,BOD)
where,
IETP = Investments in effluent and sewage treatment plants
PD = Population Density
T = Technology
BOD = Biochemical Oxygen Demand

As the aim was to capture the multifaceted relation between these factors at the micro level, the data was collected at the district level for the years 2001,2006 and 2010, through which the Yamuna flows, till, before Allahabad. Nine districts were identified corresponding to the monitoring stations, in the respective states of Haryana, Delhi and Uttar Pradesh. The districts identified are as follows: Yamunanagar, Rohtak, Mewat, Delhi, Moradabad, Mathura, Agra , Etawah and Auraiya.

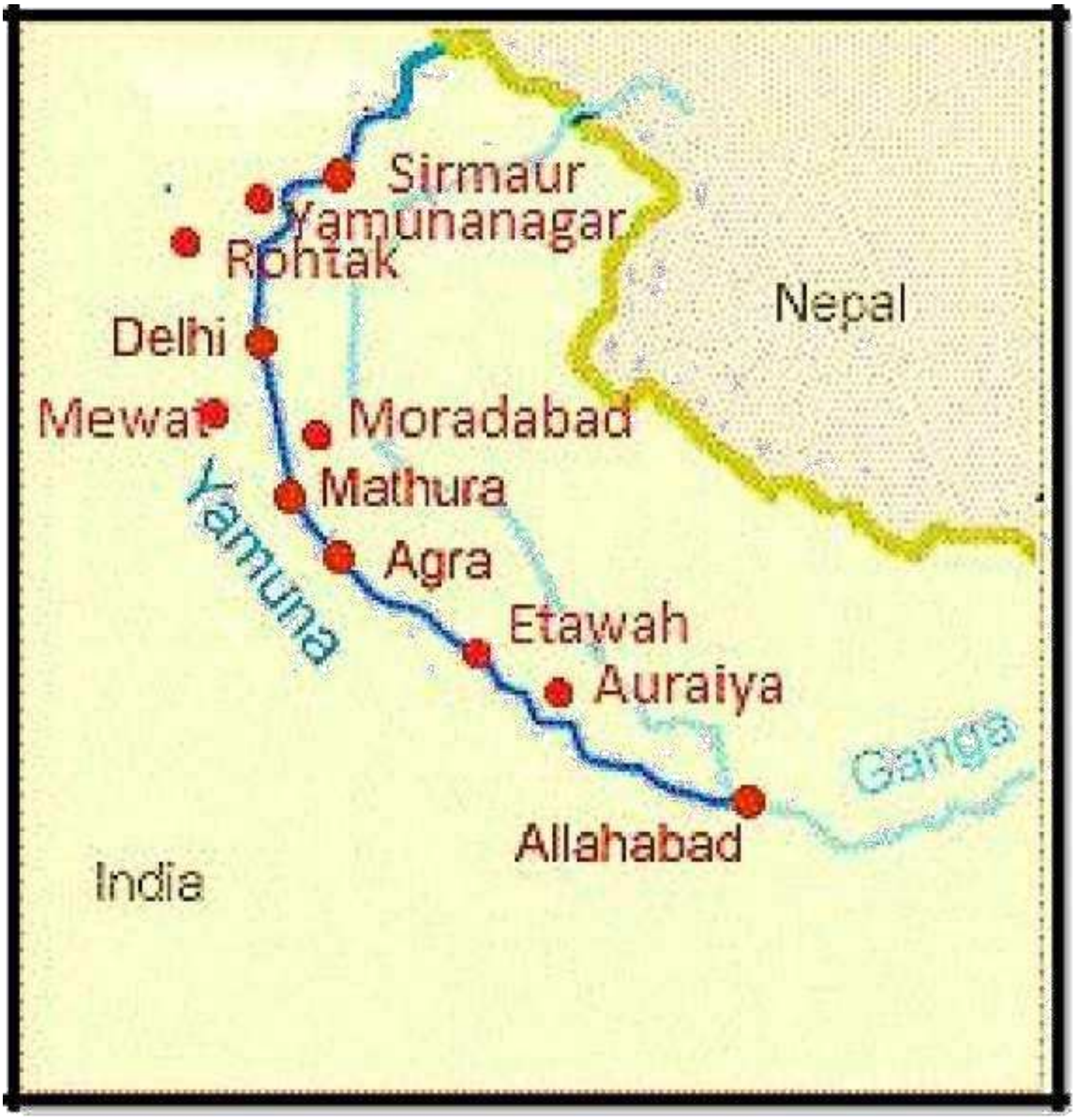

Figure 1: Map of river Yamuna, depicting the districts included in the study

Data for Biochemical Oxygen Demand (BOD), a proxy for environmental degradation was collected from the CPCB website. Biochemical Oxygen Demand (BOD) refers to the amount of oxygen that would be consumed if all the organics in one litre of water were oxidized by bacteria and protozoa(ReVelle 1988).Hence, a high BOD implies a deteriorating water quality. According to CPCB, the maximum amount of BOD should be 3mg/l or less at 20°C in an interval of 5days (CPCB website).

Population density (PD), defined as the number of people living in per unit of an area is obtained by dividing the total population of the corresponding district by the area of each district. The data for population of districts has been extrapolated from the census data given in Census report of India.

The variable number of industrial units (ID) is considered as a proxy for industrialisation. The data source for this variable is Ministry of Small and Medium Enterprises (MSME). Due to availability of discontinuous data for a few districts, some of the data has been inferred from the given data.

Literacy rate(LR) has been taken as a proxy for awareness amongst people, under the assumption, that awareness amongst people about the degradation of natural resources will have an impact on water quality (environmental degradation).The data for this was quite readily available from Census report of India.

Technology used in Effluent treatment plants/sewage treatment plants (T) has been acquired from NRCD. It was noticed, in case of River Yamuna, on an average two technologies are used, namely: Up flow anaerobic sludge blanket (UASB) and Activated sludge process (ASP). We have assigned dummy variables for technology (T), where districts which use UASB, have been assigned, T= 1 and those using ASP have been allocated, T= 0.Apart from Delhi, UASB is used in the rest of the districts.

One of the major concerns while formulating the model was finding a variable that will correctly reflect the functioning of institutions (strictly for water resources). Investments in effluent treatment plants and sewage treatment plant (IETP) solve this difficulty. As theoretically it is a well-functioning institution which directs successful investment in preventing the water quality from getting degraded. The data source for this variable is NRCD.

The rationale behind considering this as a variable which precisely exhibits properly functioning institutions is as follows. With the increase in population and industrialization, a large part of the freshwater is withdrawn for consumption and industrial purposes. Around 92 per cent of the pollution is caused by the used water being discharged into the river untreated. In such a scenario, if investment in ETP/STP, leads to an improvement in water quality, will imply that institutions through which such investments take place (specifically, in this case, CPCB or NRCD) are functioning properly. Therefore, higher investments in ETP/STP in such a scenario, will lead to an improved water quality, in an ideal situation, if there are no governance issues, which leads to institutional failure. We also expect that a fall in water quality will lead to higher investments, and thereby assuming that these two variables are endogenous or determined simultaneously.

4.RESULTS

The results for the two cases are as follows:

CASE I (MULTIPLE REGRESSION)

Dependant variable: BOD

Name of the independent variable	Coefficient
Investment in ETP/STP(IETP)	-0.000071
Literacy rate (LR)	-0.2827813**
Population Density (PD)	0.007195***
Number of industrial units (II)	0.0012753**

*= significant at 10%
**= significant at 5 %
***= significant at 1 %

Table 1: Results of CASE I (Multiple regression)

Population Density (PD) contrariwise, influences BOD positively at 1 % level of significance. A higher population density, leads to a higher BOD and hence a lower water quality.

BOD is altered by number of industrial units (II) positively. The more number of industrial units in a particular district the poorer water quality, that is, higher the BOD level.

CASE II (SEM)
Endogenous variable: BOD

Name of the independent variable	Coefficient
Investment in ETP/STP(IETP)	-0.0061157
Industrial units(II)	0.0020443**
Literacy rate (LR)	-0.6201655**
Technology(T)	-24.7591**

Table 2: Results of CASE II (SEM); endogenous variable: BOD **= significant at 5%

Endogenous variable: Investment in ETP/STP (IETP)

Name of the independent variable	Coefficient
BOD	300.6567
Population Density(PD)	-6.55609
Technology(T)	-10216.22

Table 3: Results of CASE II (SEM); endogenous variable: IETP

As we desired to analyse further and check for interdependence between BOD and investment in ETP/STP (IETP) (the relation already explained in data description and methodology section), therefore a Simultaneous equation model is run.

In the case, where the endogenous variable is BOD, we realize again in this case, that although, an increase in investment in ETP/STP (IETP) will lead to a fall BOD levels, as they are negatively related, but in this case also, the result is not significant.

An increase in industrial units, in this case as well, affects BOD positively. If the number of industrial units increases, we assume given their production leads to an increase in effluents and given everything else remains constant including investment in ETP/STP (IETP), industries dispose their effluents untreated into the water bodies leading to degradation of the water bodies, thus an increase in BOD. This result is highly significant at 5%.

Similar to Case I, an increase in awareness (where Literacy rate (LR) is a proxy) amongst people leads them to think twice before disposing off waste into the river leading to a fall in BOD, and enhancing the water quality and state of the natural resources in general. The result being significant at 5%.

For technology (T), as mentioned in the preceding section, we have considered two technologies, and used a dummy variable for it.

If UASB, T = 1

If NOT UASB (ASP), T=0

Therefore, we conclude from the results, that if UASB as compared to ASP is used, then it helps reducing the BOD to a greater extent, given everything else is constant. We can infer that UASB is a better technology when it comes to improving the water quality at a level of 5% significance.

In the case, where Investment in ETP/STP (IETP) is considered, neither BOD, nor Population density (PD) or Technology (T) affects it significantly.

5.CONCLUSION

From both the cases the following is concluded:

Water quality deteriorates with an increase in the number of industrial units. A study was carried out by Phiri et al (2005) in Malawi to assess the extent of chemical pollution in a receiving river as affected by industrial effluents. Both the effluents and the water at selected points in the river were analysed for BOD levels along with other water quality parameters. The results suggested that the water in the river was polluted and not good for human consumption. It is therefore recommended that the careless disposal of the wastes should be discouraged, the continued discharge of the effluents in the river may result in severe accumulation of the contaminants and, unless the authorities implement the laws governing the disposal of wastes, this may affect the lives of the people.

Secondly, Literacy rate(taken as a proxy for awareness), helps in improving the water quality by making people more aware about the problems(health etc.) related with a deteriorating water quality. This result is consistent with the study done by Goldar B and Banerjee N (2004) particularly for the case of Indian rivers. According to them, significant positive relationship is found between the rate of increase in literacy level in a district and the water quality in rivers flowing through the district. Although, the Yamuna Action Plan website mentions a lot of plans being carried out, to make people conscious about environmental, the Indian Environment portal articulates that Yamuna Action Plan (YAP) is not doing enough to raise public awareness.

In the SEM model we realize that UASB (Up flow anaerobic sludge blanket, taken as a dummy variable=1) technology helps in the reduction of water pollution more than the ASP (Activated sludge process, dummy variable=0) technology. Khalil (2008) mentions UASB has been recognized as one of the most cost effective and suitable sewage treatment process considering the environmental requirements in India. Reduced capital costs, increased durability of the reactors and simple operation and maintenance are some of the features which make this technology favourable. Also, there has been complete know-how & knowledge transfer in the design & implementation of UASB reactors indigenously over the years.

However, there are a number of issues which have emerged from the past 2 decades of experience of operation and running of UASB based sewage treatment plants in India which is outlined as under:

• Sustainability

• Policy matter and regulatory aspects

• Institutional framework

• Monitoring of assets and Training

• O&M aspects

• Water quality aspects

Out of these, regulation regarding indicator organism (faecal matter) is considered to be the most serious (Pant et al., 2002) as it has emerged recently apart from sustainability, monitoring and O&M issues. The intestinal pathogens and coliform are obligate anaerobes and unlike in an activated sludge plant, their die off rate in UASB environment is low. Institutional strengthening and involvement of local urban minor bodies for the operation of assets is another important issue. The engineers of ULBs and Jal Sansthans (operating agencies under YAP) have little prior experience or knowledge of the STPs created under the project.

Despite these flaws, based on the life cycle cost evaluation of sewage treatment technologies, it can be concluded that UASB still offers the best proposition compared to other treatment systems in India.

Finally, and the most important, BOD and investment in ETP/STP seems to be uncorrelated. It is not surprising, given Sharma and Kansal (2011) mentions that sewage treatment capacity under YAP-I were formulated for 1997 population loads without considering any population projection. Also it has been observed that despite of the continuous efforts to minimize the pollution load still the BOD is increasing. Biswas (2012) correctly points out that, currently 8,444 MLD of wastewater is generated in the Yamuna river basin, out of which about 4,458 MLD is discharged directly into the Yamuna river and about 1,200 MLD is discharged into its tributaries remaining 2,786 MLD is either disposed of on land or used for irrigation. CSE (2009) further supports, declaring that the growth in sewage treatment capacity has not kept pace with the increase in population and waste.
Apart from these issues regarding sewage treatment plants (STP), CPCB also reports (1999-2005) that sometimes connection of STP with the river poses great threat to water quality during non-operation of STP due to unavoidable reasons e.g. power failure, mechanical problems or maintenance of plants. In such cases the collected sewage is generally bypassed and discharged into the river at few locations without any treatment.

This problem is very significant in those stretches of river where the STP's are located upstream of the river e.g. Mathura-Vrindavan and Agra. The discharges from these STP's located upstream from water abstraction point have impact on the water quality making it unsuitable for various human activities occurring downstream of these STP's.

Also, to maintain the water quality of the river within the bathing class standard, nearly 10 times the discharge of the fully treated municipal waste water is required (Nallathiga,2011).Otherwise, no amount of treatment can bring the qualities of Fresh natural water in a river. The river needs dilution capacity – minimum ecological flow at all costs. Any river does. Upadhyay and Rai(2013) remarked, even if treated effluent quality is achieved at 10 mg/l BOD for the entire existing treatment capacity in Delhi alone, still BOD load would be 179 t/d, which may result in BOD concentration of 46 mg/l in the final effluent and not complying with the prescribed standards, due to inadequate water supply. Even if the entire sewage of Delhi is treated to a level of 5 mg/l of BOD, still the BOD load in the final effluent would be 19.4 t/d, which may continue to impair the water quality of the river.

Therefore, in short, main issues related to sewage management are:

- STPs capacity is inadequate as compared to the generated sewage.
- STPs are in general practically not meeting their compliance.
- Under running of most of the STPs due to lack of sewer connections.
- Improper drainage system.
- Excess BOD concentration coming to the plant due to inadequate water supply.

In addition, one of the major factors responsible for the shortcomings of the YAP underscores the fact that any large-scale pollution abatement program conceived at the macro level requires not just collaboration with local institutions but also capacity building and public participation to adequately deal with diffuse sources of pollution (Das et al, 2012).As Murty and Markandya (2011) discuss economic instruments, command and controls are instruments of formal regulation. The designing and implementation of these instruments involves a top down or a centralized approach. The success of these instruments in controlling pollution depends upon the quality of governance and its ability to incur high transaction costs. A bottom-up or decentralized regulation involving civic society, local communities and with a very limited role of the government could save transaction costs and get rid of political and bureaucratic corruption.

Hence there is a major flaw of YAP in all aspects of design, implementation, monitoring, evaluation, and regulation.

Although if yearly data was available, a better analysis could have been done by introducing lags to improve results. This is something that can be done in the future as an extension of this study.

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ANNEXURE

Descriptive statistics of a Panel dataset:

Name of the variable: **BOD**	Mean	Standard deviation	Min	Max
Overall	10.3	8.788323	1	28.3
Within		1.876397	8.5	12.24444
Between		8.648531	- .4444444	26.64444

Name of the variable: **POPULATION DENSITY (PD)**	Mean	Standard deviation	Min	Max
Overall	927.0665	644.6481	472	2826
Within		28.52761	896.7661	953.4078
Between		644.2109	502.3003	2856.3

Name of the variable: **LITERACY RATES(LR)**	Mean	Standard deviation	Min	Max
Overall	70.88704	10.71099	45.74	88.7
Within		5.814679	66.54556	77.49333
Between		9.556051	49.29782	86.16148

Name of the variable: **INVESTMENT IN ETP/STP (IETP)**	Mean	Standard deviation	Min	Max
Overall	875.2144	1338.675	0	5292.97
Within		57.09941	836.8595	940.8356
Between		1337.831	-65.62116	5227.349

Name of the variable: **NUMBER OF INDUSTRIAL UNITS (II)**	Mean	Standard deviation	Min	Max
Overall	2220.556	2361.895	0	9087
Within		1045.518	1319.444	3366.869
Between		2195.855	- 1139.333	7940.667

Name of the variable: **TECHNOLOGY (T)**	Mean	Standard deviation	Min	Max
Overall	0.8888889	0.3202563	0	1
Within		0	0.8888889	0.8888889
Between		0.3202563	0	1