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Analysing the Effect of Industrial Waste on River Ravi

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Abstract: In the research on river Ravi, I tried to find out the effect of industrialization that has turned the river into a sewer. The finding of my research were: a) Industrial pollution is present in the river but its harmful effects were not seen as most of the pollutants are washed and diluted during the monsoon season. b)Fluoride in the river water was the main cause of bone deformity disease that hit a downstream village in 1999. Prior to this, no study on the river has actually considered Fluoride as a potent threat. Studies on river Ravi so far suggested that the concentration of certain elements, ammonia and faecal coliform are high. However, none of the studies have taken into account fluoride concentration, which eventually had a phenomenal effect on the village downstream. The studies, findings and finally the outbreak of disease conveyed that not all the parameters were taken into account during the studies. Fluoride concentration could have long been detected if concentration of all possible heavy metals, trace metals and toxic chemicals had been tested.

Key words: Economic cost, industrial pollution, industrial waste, polluters pay principal, soft system methodology, wastewater management, wastewater treatment

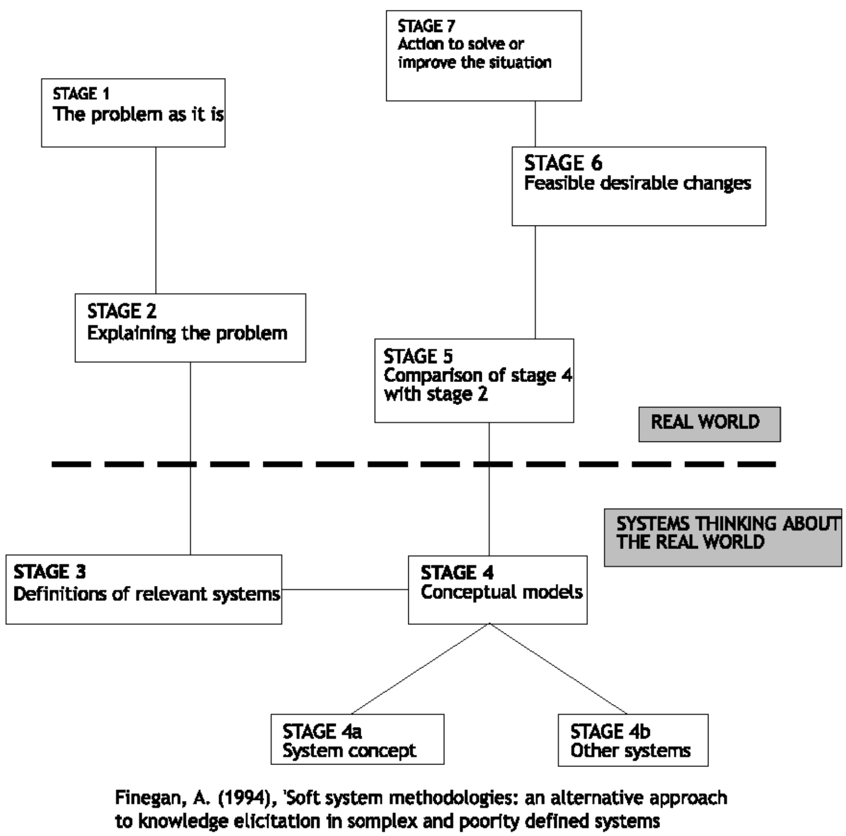
Introduction

The rate of industrial pollution is increasing in developing countries and is one of the main threats to human health and crops. Studies have shown that nine-tenth of all the sewage in developing countries enters directly into rivers, lakes and seas without any treatment. On a global scale rivers are dumping twice the amount of organic matter into the oceans as compared to pre-human times (Villiers, 1999). In developing countries, water from rivers serves the needs of irrigation, drinking, cooking and washing, whereas rivers themselves were used for dumping city wastes. Time and increase in urban population has changed the nature and characteristics of the rivers. One such river is the River Ravi that flows beside Lahore, the second largest city of Pakistan.

River Ravi in the past decade has changed tremendously. It has lost its vigour that once was its identity. Much has to do with the Indus Water Treaty of 1960 with India but lack of concern, ill management and industrial pollution have also transformed the river into a large sewage channel. Not much work has been done in monitoring the pollution level to which it owes its present state. It seems that those concerned have accepted the fate that not much could be done in this regard, or perhaps improving the water quality of the river is not an issue of concern.

Against this background the essay tries to analyze the impact of industrial waste dumped into the river in order to see what could be done in improving the situation. The research essay on one hand deals with the theoretical aspects of wastewater treatment and on the other tries to find some practical measures in achieving this goal. Since the paper is about analysis, it will examine the structure of the problem and look into some past and recent data to ascertain the cause of the problem. The underlying principle around which the paper revolves is that of welfare economics, the study of how the allocation of resources affects economic well being (Gans, 2000).

In order to pursue further with the analyses, there is also a need to develop a simple analytical model that portrays interconnections between important elements of the situation (Field, 2001). A model is necessary, as it would work as an explanatory medium for the underlying principle of economic well being. The model used here is based on systems analytical approach. It is an approach that tries to solve the problem by focusing on the entire system, rather than on its individual components (Stiff, 1980). The methodology used is based on Soft System Methodology (Finegan, 1994) that tries to provide an effective and efficient way to carry out a system analysis of various processes through various stages (Appendix I).



Appendix I: Soft System Methodology

The essay is divided into two parts: the first part gives an analysis of the surveys and tests conducted on the industrial wastewater of the river and the second discusses whether global wastewater management and treatment practices could be applied to change the present situation in river Ravi. The main focus of this paper is to investigate whether industrial wastewater treatment is required considering the present state of industrial pollution in the river and what measures, if any, could be used to improve the situation.

The water treaty with India

The water treaty between Pakistan and India is a significant policy instrument as it contributes to the natural low flow rate of the river. Ravi originates from India in the State of Himachal Pradesh. It enters Pakistan a few kilometres away from Lahore and passes along Lahore to join river Chenab after covering 640 km (Ahmad and Ali, 1998) and eventually merges with river Indus (Fig 1). Its width ranges from one to two km and depth from four to six m. Research and references have recorded that in the 1930s the river had 34 species of fish (SDNPK, 2001).

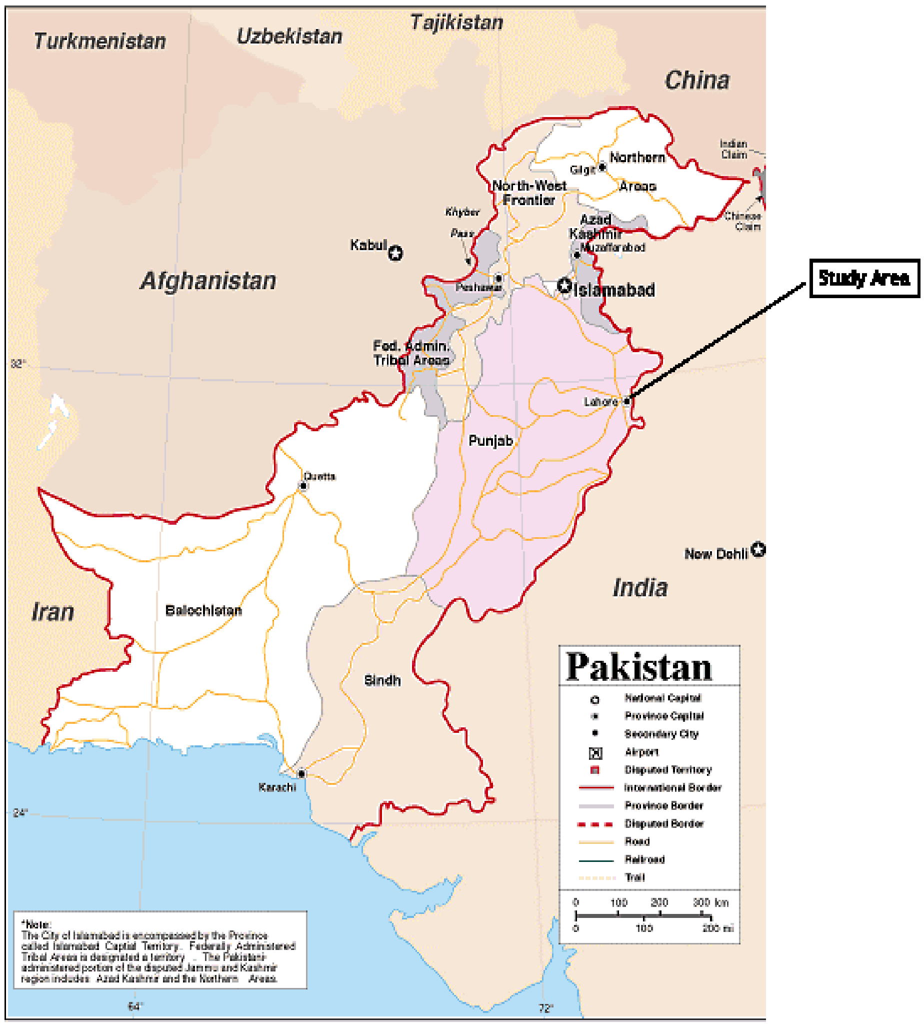
Under the Indus Water Treaty of 1960 between Pakistan and India, control of the three eastern rivers of Pakistan, namely, Sutluj, Bias and Ravi have been given to India (Michel, 1967; Ohlsson, 1995). This treaty came into being under the auspices of the World Bank and after a series of much debate and discussion between the two countries. The treaty authorizes India to use the water of these rivers. Therefore, it is obvious that due to this agreement and with the increase in population over time more and more water is consumed on the Indian side and less is left to flow towards Pakistan.

In order to improve the rate of flow in the river, it is connected by a number of canals. One such canal from River Chanab is Marala-Ravi link canal and because of it flow in the Ravi is maintained even in dry season (ADB, 1995). The other two canals responsible for maintaining a reasonable flow are present at 42 and 60 km downstream of Lahore (Ahmad and Ali, 1998) (Fig. 2).

Industrial pollution in River Ravi

The situation in Ravi has deteriorated over the years. The industrial waste from India, industrial waste produced by Lahore and negligible flow of the river has contributed significantly to its near demise. The waste produced by Lahore has increased manifold over the years. Much has to do with its population which, from less than a million in 1947, has jumped to more than seven million in 2000 (UN, 2000).

Lahore is comprised of urban and rural areas where the increase in population is concentrated more in the urban centre. The growth rate of the city for past 17 years from 1981-1998, has been 3.46%, which is considerably higher than the population growth rate of the country which, stands at 2.6% (GOP, 2001). The urbanisation growth trends could be due to a global trend as pointed out by United Nations Environmental Program in its study (UNEP, 2000). The fact remains that as cities grow, the surrounding land once used for agriculture or natural habitat is taken over by residential areas, roads and industry. The cumulative effect of the population and infrastructure thus appears in urban areas in the form of waste and particularly in Lahore, as untreated waste ending up in soil or water channels.



Source: DSE (2002), German foundation for International Development

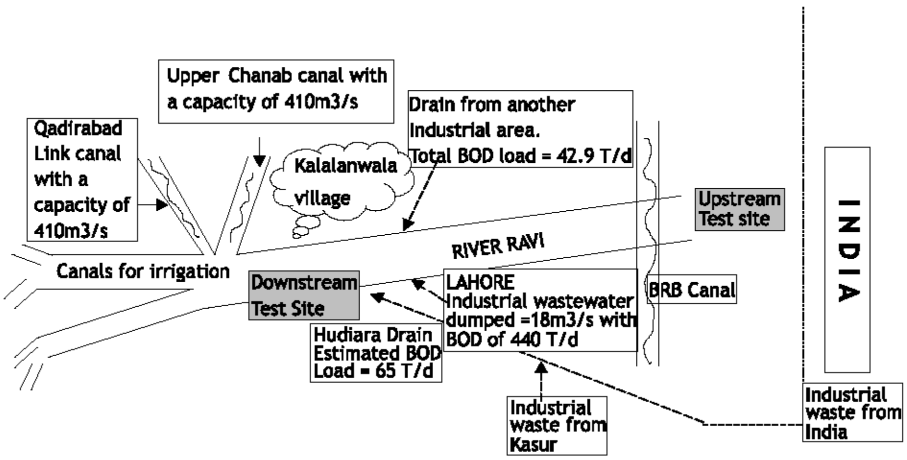
Fig. 1: Pakistan and its major tributaries

Pollution statistics

The data on water pollution reveals that a major increase in water pollution had occurred in Lahore over the years. Industries belonging to Food and Beverages (39%) and textiles (30%) contributing mainly to the pollution (World Bank, 2001). Pakistan being an agrarian country, the pollution level further intensifies due to the annual increase in fertilizers and pesticides (ADB, 2001). The topography of the area is such that the river passes through most of the fertile land.

As the nutrients from the water contribute to agricultural land, the chemicals from fertilizers and pesticides add to its effluent levels.

The Asian Development Bank did a series of tests on river Ravi to show the level of various pollutants in it during 1996 and 1997 (Appendix II). The results showed a low percentage of oxygen and increased turbidity in Ravi. It showed no concentration, even any traces, of industrial chemicals such as lead, cadmium and mercury, which are considered highly toxic in water. The result showed that all the values have been within the limits set by the NEQS (National Environmental Quality Standards) of Pakistan EPA (Environmental Protection Agency).



Source: Adapted from Pearce et al, (1998), 'A simple methodology of water quality monitoring'

Fig. 2: Location of the sites

Appendix II: Pollutants in River Ravi I

Location	Subject	Year	Value	Status
Ravi River, (BRB Ravi Siphon)	Concentration of BOD (mg l^{-1})	1996	1.8	One time data
	Concentration of COD (mg l^{-1})		6.5	One time data
	Concentration of Lead (mg l^{-1})	1997	-	Not Traceable
	Concentration of Cadmium (mg l^{-1})	1997	-	Not Traceable
	Concentration of Mercury (mg l^{-1})	1997	-	Not Traceable
	Concentration of Suspended Solids (mg l^{-1})	1996	142	One time data
Lahore	Annual Average Maximum Temperature	1994-1996	30 (°C)	
	Annual Average Minimum Temperature	1994-1996	18(°C)	
	Annual total Rainfall (mm)	1993	542	
		1994	827	
		1995	1296	

Source: Adapted from Asian Development Bank Data System Division (ADB, 2001)

BOD is the Biological Oxygen Demand and is the biological measurement of the amount of oxygen used by microorganisms in water as they decompose the organic matter (Best, 1977)

COD is the Chemical Oxygen Demand and is the measurement of chemical compound present in water

Another study (Ahmad and Ali, 1998) done in 1997 checked both the upstream and downstream biological oxygen demand (BOD) and chemical oxygen demand (COD) contents. The results of the study showed that both these variables are high in the river. Moreover it was pointed out that industrial waste is not only dumped in the river by the industries of Lahore but effluents from an industrial site opposite the city and from Hudiara Drain also adds to the menace (Fig. 2).

In 1998 a third report by Pearce ***et al.*** (1976, 1998) showed for the first time an indepth analysis of water quality in river Ravi. Various sites on the river were taken to determine the water quality; however, as the scope of this paper is limited to the effect of industrial wastewater, two sites on the river will be discussed. One is chosen upstream a few km. away from the industrial zone and the second downstream of the river where the industrial effluents of Lahore and its surrounding industrial areas entered the river (Fig. 2). A number of tests on flow rates, temperature and concentration of various chemicals were conducted (Appendix III).

Appendix III: Pollutants in River Ravi II

Test	Location	Highest value during the year	Lowest value during the year	Annual Average value	Remarks
Flow rate	Upstream	900 cusecs	50 cusecs	500 cusecs	Monsoon rains increased the flow, which provides a flushing effect to the system.
	Downstream	1600 cusecs	100 cusecs		
Electro conductivity	Upstream	0.36 ds m^{-1}	0.22 ds m^{-1}	0.3 ds m^{-1}	Within irrigation standards
	Downstream	0.52 ds m^{-1}	0.21 ds m^{-1}		
Temperature	Upstream	30°C	12°C	19.8°C	Due to prolonged summer and higher temperature micro-organisms were able to proliferate at much faster rate.
	Downstream	28°C	12°C		
Dissolved Oxygen	Upstream	10 mg l^{-1}	2 mg l^{-1}	5.75mg l^{-1}	The limit for dissolved oxygen is 4 mg l^{-1}. At 5.75 mg l^{-1} fish becomes rare in that part of the river.
	Downstream	13 mg l^{-1}	3 mg l^{-1}		
Nitrate	Upstream	0.5 mg l^{-1}	0.09 mg l^{-1}	0.2 mg l^{-1}	The Nitrate level is relatively low and is not an issue.
	Downstream	0.61mg l^{-1}	0.02 mg l^{-1}		
Ammonia	Upstream	0.85mg l^{-1}	0.05 mg l^{-1}	0.37mg l^{-1}	It is high downstream but the readings are within the limits (0.4) set by the National Environmental Quality Standards (NEQS).
	Downstream	1.3 mg l^{-1}	0.05 mg l^{-1}		
Phosphate	Upstream	1.0 mg l^{-1}	0.01 mg l^{-1}	0.4 mg l^{-1}	Within the limits set by NEQS
	Downstream	0.62mg l^{-1}	0.07 mg l^{-1}		
Chromium VI	Upstream	0.19mg l^{-1}	0 mg l^{-1}	0.05mg l^{-1}	Within the limits set by NEQS, that is 1.0 mg l^{-1}
	Downstream	0.07mg l^{-1}	0.005 mg l^{-1}		
Chromium III	Upstream	0.21mg l^{-1}	0.03 mg l^{-1}	0.07mg l^{-1}	Within the limits set by NEQS, that is 1.0 mg l^{-1}
	Downstream	0.12mg l^{-1}	0.03 mg l^{-1}		
Faecal Coliform	Upstream	1000 cfu/100 ml	50 cfu/100 ml	570 cfu/100 ml	Data unreliable
	Downstream	1000 cfu/100 ml	50 cfu/100 ml		

Source: Adapted from Pearce *et al.* (1998), A simple methodology of water quality monitoring

The study showed that most of the chemicals tested complied with the environmental limits set by NEQS except for the high percentage of dissolved oxygen that indicated towards a badly polluted river. The study did not found any significant concentration of heavy metals at any site and concluded that the level of heavy pollution from Lahore and its vicinity is low as there was sufficient dilution from waters added to Ravi (Pearce ***et al.***, 1998). Heavy metals from the industry though present in traces were absorbed by heavier sediment particles and deposited on the riverbed rather passing down the system as suspended particles.

Analyses of studies

The results of the report by ADB (2001) are objectionable in many ways. It is taken on a one-time basis in 1996 and 1997, showing that there is no system of periodical monitoring of the river. The site chosen for testing data (BRB Ravi Siphon, Fig. 2) is a few km. upstream of the city. The water at this particular location is much clearer, which shows that any pollution present is either washed up or diluted as at this point a main canal from River Chenab enters Ravi. The study by the ADB is limited in the sense that it worked on some wastewater chemicals and covered only a few aspects of industrial pollution.

The results of Pearce ***et al.*** (1998) had a number of flaws in the above tests. The data for water flow and temperature had been collected for the whole year whereas data for all other tests had four or five months missing. Secondly, the data collection team was not equipped with equipment to test heavy metals from the riverbed. Thirdly, the study did not considered biological indicators; and lastly, the authors admitted that some data collected was not reliable. Despite the number of flaws in each test it can be concluded from these studies that the river and added water from link canals are somewhat successful in treating the bacteria derived from industrial wastewater.

It is evident from the studies that apart from the increase in BOD, COD and suspended particles levels, there is not much evidence of any other factor responsible for industrial pollution. However, the discussion does not end here. In a small village, named Kalalanwala (Fig. 2), people suffered from bone deformity and stiffness of joints. The village made headlines in 2000 when many of its inhabitants were admitted to the hospital due to severe joint pains and deformed limbs. Investigation revealed that industrial waste dumped in the river had polluted the well water. According to the Pakistan Council of Scientific and Industrial Research Centre, the water sample in the river near the industrial area showed fluoride levels at 5.26 to 26.32 mg l^{-1}, as compared to the permissible level set by World Health Organisation of 0.7 to 1.7 mg l^{-1} (Inter Press Service, 2000). Lahore disposes off 240 million gallons of wastewater per day or 18 cm^3 sec^{-1} (Ahmad and Ali, 1998) and according to NEQS the normal level of BOD in river is 80 mg l^{-1} whereas in Ravi it is 100 to 193 mg l^{-1} (SNDPK, 2001).

Studies so far suggested that the dissolved oxygen levels are high and so is the concentration of ammonia and faecal coliform (Pearce ***et al.***, 1998; Ahmad and Ali, 1998). However, none of the studies have taken into account fluoride concentration, which eventually had a phenomenal effect on Kalalanwala Village downstream. That brings us to the question whether the tests conducted for various studies considered all possible variables and whether the frequency of testing and monitoring was sufficient or not. Another problem with the studies was that of incomparability as each study had used different parameters from the other, making it impossible to compare. The data is also conflicting, as SNDPK (2001) states the BOD level in the river to range between 100 and 193 mg l^{-1}, whereas another report by the Ministry of Environment gives it at 300 mg l^{-1} (Pak.EPA, 2001).

The studies, findings and finally the outbreak of disease conveyed that not all the parameters were taken into account during the studies. Fluoride concentration could have long been detected if concentration of all possible chemicals had been tested. This also means that there is a possibility of some other element, besides fluoride, that can be a potent threat to human health. After all no one suspected fluoride to be a threat before it emerged in Kalalanwala.

Once analyzing the data and knowing the present status of the river the next logical step would to see what could be done about it. This takes us to second part of the paper, which looks into various aspects of wastewater management techniques, treatment facilities and economic issues to further broaden up our knowledge and to explore the possibilities of improving the present situation by introducing these techniques.

Wastewater management

Development of wastewater management services requires an improved planning process that suits the social, ecological, cultural and economic needs of the area. Some significant principles governing recent wastewater management practices are as follows:

Separate handling of recyclable waste

It is important that industrial waste should not be mixed with other wastewater in order to make wastewater treatment cost-effective and recyclable (Karrman, 2001; Bakir, 2001). In the case of Lahore a separate study is required to analyze whether separate handling of recyclable industrial wastewater could prove beneficial for agriculture, as most of this water is loaded with nitrogen, phosphorus and potassium, all of which is vital for plant growth (Akhtar, 2001).

Use of energy efficient techniques

The system handling industrial waste is favourable near villages as biogas (methane) and heat from the wastewater can be used and less contaminated water can be used for irrigation (Bakir, 2001). In case of river Ravi, a waste-to-energy project under the auspices of the World Bank Global Environmental Facility was to be installed in 1995. However, due to differences between the Bank and the provincial government over the selection of the site, the work on the project ceased after completion of feasibility reports (SWECO, 1994).

Decentralised management

This is a recent approach that involves small treatment plants to be installed instead of one large centralised station (Bakir, 2001). The cost of the smaller plants could be more than one plant but the operation and maintenance of smaller plants would cost less than for one centralised station. Currently this approach has been found successful in Muscat (Oman) where the treated water is used for urban landscaping through extensive drip irrigation (Bakir, 2001).

Minimum effluent standards

Minimum effluent levels are required so that industrial discharge must meet the laid-down criteria. In the European Union the wastewater treatment directive is the main legislation for the control of urban pollution (Zabel ***et al.***, 2001). Environmental legislation for effluent standards does exists in Pakistan but forcing industry, which also makes a strong pressure group in the countrys politics, to obey NEQS requires planning, incentives and some tradeoff (Yazdani, 1998).

One successful example of wastewater management is near Lahore. Kasur Tannery Pollution Control Project is situated in a small town of Kasur (20 km from Lahore) that monitors and controls the polluted tannery water (UNIDO, 2001). The project has established a wastewater treatment plant, chromium recovery solid waste disposal site and a management system with a cost of $US 10 million through UNDP and UNIDO. The plant is being run on the polluters-pay principle and is undergoing a process of taken up by local authorities and private sector.

Wastewater treatment

The wastewater treatment facility for industrial wastewater is another aspect that needs considerable attention. The process of wastewater treatment carried out, largely by microorganisms, is basically oxidation and could result in complete depletion of oxygen in water (Cotter, 1976; Ahmad and Ali, 1998). The process stops at a certain stage due to lack of oxygen and the remaining unoxidised matter is the real cause of damage to the environment (Cotter, 1976). Wastewater and the leftover sludge produce methane, which is mostly released to the atmosphere (SWECO, 1994).

The most effective technique for reducing these emissions is to implement effective aerobic wastewater treatment systems (USEPA, 1993). However, if the wastes are treated under anaerobic conditions (without oxygen), methane and other gases can be recovered. Besides conventional methods, other methods are also used to treat industrial waste, such as, Lake Orta in Italy (in 1989-90) was treated with 14,500 tons of limestone. This increased the pH level of the lake from 4 to 6 (Beltrami ***et al.***, 1999), reduced pollutant loading and had improved conditions at the water-sediment interface. The example in terms of cost-effectiveness and with no industrial wastewater treatment plant can be applied to River Ravi. However, it is not sure how to control limestone from flushing away in the river.

Is industrial wastewater treatment cost-effective?

The remedy of industrial pollution lies simply in building a wastewater treatment plant; however, the treatment costs money, time and effort is the point where it touches a common citizen. Another problem that makes the issue of dumping industrial pollution in river more complex is that river itself is a highly complicated ecosystem (Fisher, 2000) and this not only make the treatment difficult but costly at the same time.

The amount of money needed for industrial wastewater treatment can be illustrated by the fact that the cost borne on river Rhine (that used t act as a drain to the North Sea from

Switzerland, Germany, France and Netherlands) exceeded the expenditure on any other river in the world and yet it is polluted (Villiers, 1999; Lanz, 1995). The work on river's restoration initiated in early 1970s and in 1986 and after spending billions on industrial affluent control and sewage treatment some progress was seen. Recently it has been seen that most of the fish have returned to the river but it is still unsafe to eat due to high mercury levels (Villiers, 1999). The other example is of Thames in London where over a period of four decades some areas of the river have been restored (Cotter, 1976). The example illustrates that river restoration and rehabilitation is an expensive and time-consuming process and that at the moment cannot be an economically viable option for Pakistan.

Monitoring of wastewater treatment

In environmental economics, monitoring and enforcement have attracted relatively little research efforts. Studies regarding the monitoring and enforcement have been recent and remain limited in number. One example is that in China in the Zhenjiang city where the impact of regulators behaviour on the environmental performance of polluters had shown that inspection reduces the level of emissions by 20% (Dasgupta ***et al.***, 1999). In case of Ravi, with a corrupt and inefficient bureaucracy, relying solely on monitoring and inspection would probably not bear desirable results (Yazdani, 1998).

Economics of industrial wastewater

The significance of economic costs is substantial in understanding industrial pollution in River Ravi. Why these costs occur is easier to explain, as pollution tends to be a by-product of economic activities. The polluter does have a choice of how much pollution to produce. The industry can reduce the scale of activity or can look for alternate technological processes by which to reduce pollution. Economically the decision to reduce pollution is tough as to reduce output means to reduce profits, while to change technologies means to adopt to a costlier process and also to reduce profits (Lal, 2001).

The interest of the industry can change if the river had enforceable and well-defined property rights. The effectees could claim damages from the polluter, but if the polluter knows that there are no property rights or loosely defined rights, as in the case of Ravi, they may well accept the risk of polluting (Pearce, 1976). Therefore defining and enforcing property rights to the river (or to all resources) is another dimension of this long-term problem of solving externalities and hence environmental problems.

Property rights and the polluter pay principle

The economic system in Pakistan does not specify property rights to the river however, it can be concluded that once the industry takes into account the external costs it imposed on others, this would reduce the scale of pollution (Bennett, 2002). The industry can add external cost to their operating costs either through strict enforcement of fines or through some other incentives. One way of introducing fines is through levying the environmental tax based on the polluter pay principle. Such taxes that are imposed to correct the effect of negative externalities are also called Pigovian taxes (Gans, 2000), after the economists Arthur Pigou (1877-1959). The logic behind the tax is to set up a pollution standard and tax industry that exceeds these standards. Economists prefer such taxes to regulation as they can reduce pollution at a lower cost to a society.

Another way of achieving the goal is to ensure that polluters rehabilitate the area or reinstate the environmental damage (Fisher, 2000), however, in practice levying tax, implementing rules and setting up optimal standards of pollution is another issue to solve. In case of Pakistan environmental legislation exist for polluters to pay but the amount of payment is minimal to deter the industries from polluting (Yazdani, 1998).

One of the practical solutions in economic management is to establish riparian rights (Riparian originates from Latin word riparius, meaning “situated on the banks of a water course”) on the river (Field, 2001). Riparian rights are the rights of landowners to the water on or bordering their property, including the right to prevent diversion or misuse of upstream water. This can be done by clearly defining boundaries to a specific area and making it as a buffer zone owned by the State or assigning that area to a community whose livelihood is dependent on that area. Clear definition is vital as it would ensure that there is no ambiguity about the nature of the right that is owned (Field, 2001). From an environmental point of view, riparian rights can involve complexities due to lack of scientific certainty and legislated rights of water (Fisher, 2000).

Some of the specific property rights problems in developing country involve inadequate markets for resource conservation and inequality in the distribution of resource property rights (Field, 2001). Considering these bottlenecks, for Pakistan it certainly demands a precautionary or adaptive approach in such a way that government ensures that property rights can be varied from time to time.

Sustainable banking

The concept of sustainable banking is recent and deals with financing cleaner technologies and environmental sound products so as to reduce waste (Jeucken, 2001). Budapest Bank of Hungary is one such example where the bank in association with the Ministry of Environment and the European Bank of Reconstruction and Development (EBRD) had created a Environmental Credit Line (ECL) to fund certain projects that generates environmental benefits (Jeucken, 2001). In case of Ravi, the approach can be used as an incentive to industry for providing loans for small treatment units.

Whatever economic methodology is applied to revive the environment, it has to be understood that economics alone cannot offers exact solutions to environmental problems since the problems themselves raise question about the relevance of the values on which economic solutions are based. It does offer certain tools and framework to work with but to expect more than this is challengeable.

Final analyses

Before analysing and passing out a judgment on environmental issues it should be borne in mind that these issues are complex and time consuming. It is also vital to mention that the theory that underpins our research in industrial wastewater management deals with human well-being and sustainability. The studies done on River Ravi showed that these studies lack data and in-depth analyses to support a sound theoretical framework. The case studies of Rhine and lake Orta, on the other hand, shows that the management process of river ecosystems are time consuming and costly. A study done by Jansen and Vergrat in 1992 (Freeman, 1997) showed that even with determined efforts these changes will require a period of thirty to fifty years. In comparison many environment policy goals related with technologies are short to medium term, but still require many years to see any outcomes.

The other problems involved in meeting environment goals is the complexity of issues and requires an interdisciplinary decision making mechanism that caters the needs of economics, environment and society. Issue such as property rights, polluter pay principle and establishing a wastewater treatment plant needs immediate attention as none of the government in Pakistan has been successful in achieving these goals. It should be acknowledged that dumping industrial wastewater in the river is an issue associated with open access to resources.

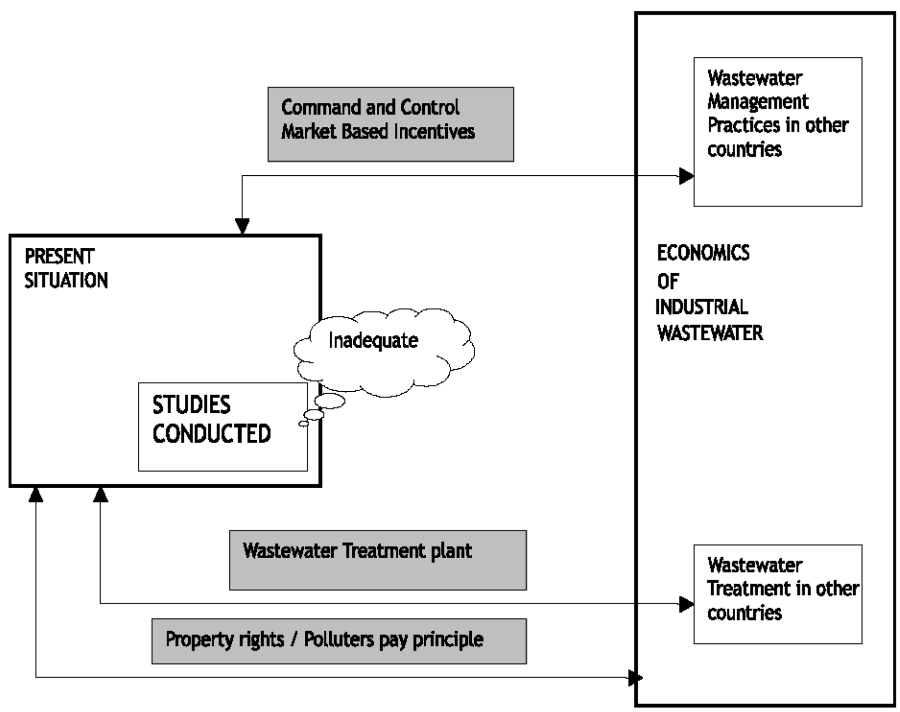
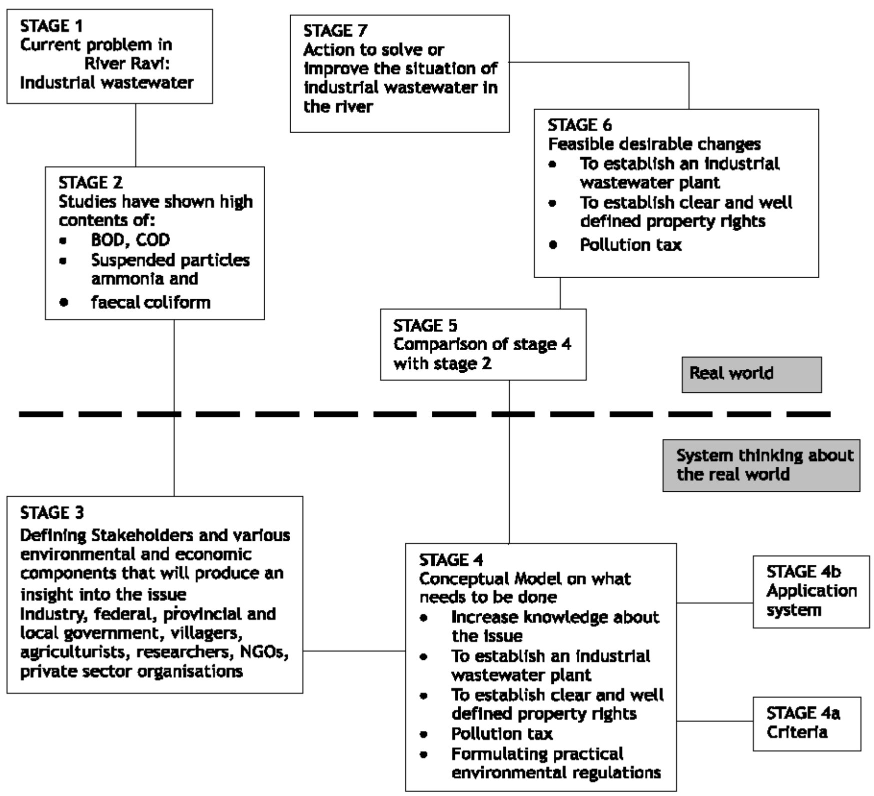


Fig. 3: The Model using Soft System Methodology

Then policy tools like direct regulations and economic instruments are also important in environmental development. Direct regulation is the most commonly used process however, they are criticised as being less effective than economic instruments (Freeman, 1997). Unfortunately in Pakistan, due to various reasons, neither direct regulations nor environmental taxes have worked positively (Yazdani, 1998). The issues that involves industrial wastewater management in Lahore also requires understanding of the issue that pollution is a by-product of economic activity that are beneficial to the society and therefore preventing it will put a cost to the society (Bennett, 2002).

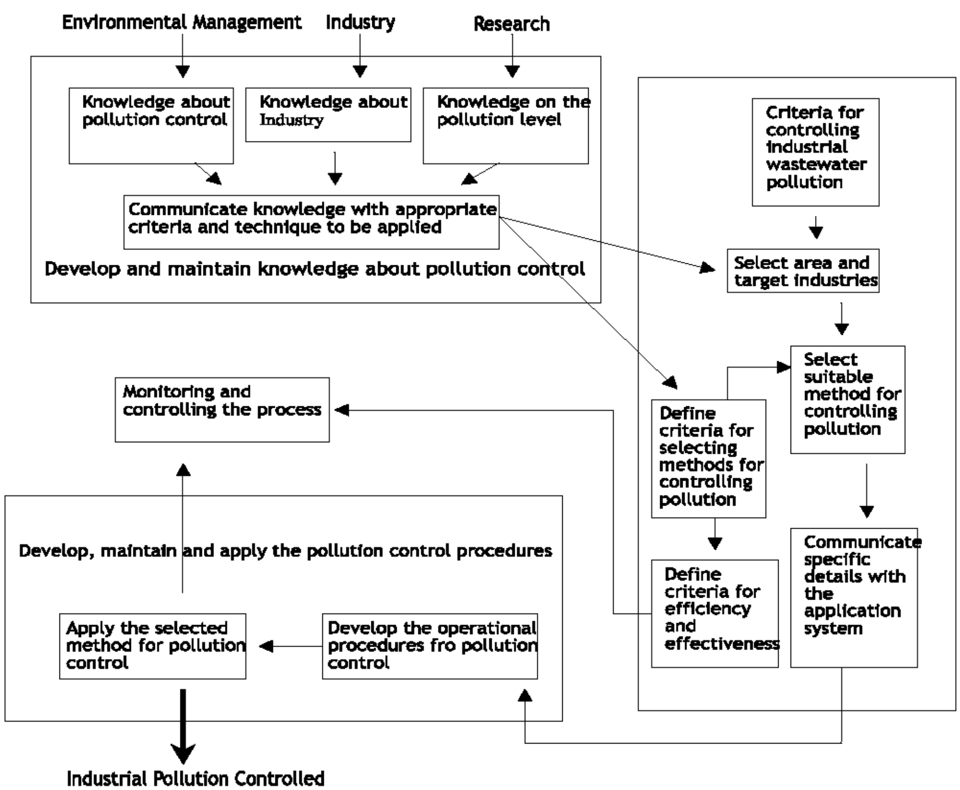
Based on the research a diagramatic presentation about the issues and possible solutions can be seen at Appendix IV. Soft System Methodology is then applied to this model to see the outcomes (Fig. 3). It was observed that despite complexities of the issue, the model identifies the ground rules that are suitable for developing an effective way to carry out a system analysis of various processes through various stages.



Appendix IV: Pollutants in River Ravi I

The details of conceptual model (Fig. 3) and its various stages can be seen at Appendix V. In view of the foregoing a rational approach is required that should involve managing and lowering down the pollution levels using technological resources, if need be flood water can e utilized in pollution control (Stauffer, 1998) and legislation. At present the prime requirement is to have an industrial waste treatment facility in order to tackle the enormous amount of untreated wastewater that threatens health of the downstream users (WWF, 2000).

A mega project of wastewater treatment plant is in pipeline with the World Bank and is expected to reduce the pollution level in the river (if implemented) to optimal level over a 15 years period. The Water and Sanitation Authority of Lahore (WASA) has so far acquired 370 h of land at a cost of US$ 3.5 million for the proposed plant in SouthWest Lahore. The treatment plant would have nine anaerobic and forty facultative ponds to be constructed in two phases. The cost estimate of the project for the proposed treatment plant is US$ 50 million (WSP, 2001). However, the project has been on the World Bank lending list for many years and the funds have so far not been made available due to reasons not revealed by the Bank.



Source: Adapted from Finegan (1994), 'Soft system methodologies: an alternative approach to knowledge elicitation in complex and poorly defined systems'

Appendix V: Conceptual Model

Recommendations

It is clear that we need an industrial wastewater treatment facility and we need it now as a definite problem is there. It can be done by generating financial resources or borrowing money from donors but before that more research is required on the effluence status to establish the gravity of the problem and to estimate a future forecast of the problem. Approaches and techniques used by other countries are helpful as a guideline however, the issue requires a pragmatic approach that suits our economy, environment and society.

On the basis of discussions a few recommendations are given below that could bring a positive change and lower the industrial pollution:

Conduct a detailed study to investigate the root cause and the industry responsible for industrial wastewater pollution.

It is vital that Lahore should have an industrial wastewater treatment plant.

To develop financial resources on self-help basis. In wastewater management it could mean that the industry polluting should be legally bound to restore the polluted area.

The pollution tax, if levied, should be taxed on reasonable grounds and the revenue collected should be in turn be used for environmental management and not in any other sector.

To establish clearly defined property rights over the river.

Formulating environmental laws and rules that are easily understood, practical, flexible and applicable. This requires institutional development within environmental law and perhaps setting up of environmental courts.

The industrial sector is an influential lobby group often backed by politician. It makes implementation of environmental regulations much harder and in most cases impossible. It is vital either to force environmental regulations or to give this lobby group some incentive for not polluting the environment.

We cannot increase the water flow from India due to the Indus Water Treaty, but we can negotiate with India to minimize the waste flowing to Pakistan through Hudiara Drain.

Pakistan can benefit from the scientific advancement in other countries but has to make decisions according to her socio-economic conditions. The soft system methodology applied is one approach that tries to provide an effective and efficient way to solve the problem. However, before this the decision makers has to decide whether to invest in small waste treatment plants or wait for the World Bank to disburse loan on a single large plant. The government has to look for alternatives and most importantly they have to decide quickly as time is not on their side.

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