Working Paper No. 40
June, 2001

'KILLING FIELDS' : LIFESAVERS AND EXTERNALITIES

(A Study of the Impact of Industrial Pollution on Rural Communities in A.P)

Bhagirath Behera
V. Ratna Reddy

CENTRE FOR ECONOMIC AND SOCIAL STUDIES
Begumpet, Hyderabad-500016

'KILLING FIELDS': LIFESAVERS AND EXTERNALITIES

(A Study of the Impact of Industrial Pollution on Rural Communities in Andhra Pradesh)

Bhagirath Behera
V. Ratna Reddy [1]

Abstract

This paper makes an attempt to study the environmental impact of water pollution on the rural communities in general and on agricultural production, human health, and livestock in particular. Direct approaches such as contingent valuation method (CVM) and indirect methods such as Effects on Production (EOP), Replacement Costs (RC), and Human capital (HC) approaches were used to estimate the damages and losses (crops, agricultural equipment and health). The study is based on primary data collected from 50 households from a village affected by industrial pollution.

It is estimated that the average annual loss to a household is about Rs. 36000, including agriculture, human health and livestock, due to pollution. The effluents from the industries that produce some of the life saving drugs have turned the surrounding villages into virtual killing fields. For, croplands have become barren, people are suffering from pollution related diseases and livestock are dying apart from other illnesses. The way in which environmental externalities have occurred can mainly be attributed to three important failures i.e., market failure, policy failure and institutional failure.

Keywords : Externalities, Industrial effluents, Pollution, Contingent Valuation Willingness to Accept, Andhra Pradesh.

---

[1] *Centre for Economic and Social studies, Hyderabad. This is a part of the first authors M. Phil dissertation submitted to the Department of Economics, University of Hyderabad, Hyderabad.*

'KILLING FIELDS' : LIFESAVERS AND EXTERNALITIES

(A Study of the Impact of Industrial Pollution on Rural Communities in A.P)

I Introduction

The most strident environmental problems facing developing countries are water pollution, air pollution, soil degradation, etc. Of these problems, water pollution poses a serious challenge due to its impact on a large number of economic activities. It is observed that 75% of the world population doesn't have access to safe drinking water. Majority of them live in developing countries. The problems of water pollution acquire greater relevance in the context of an agrarian economy like India.

Industrial pollution has been one of the most important factors causing water pollution. Industries release their effluent to the water bodies, which contain chemicals and biological matter that impose high demands on the oxygen in the water. That is why, polluted water contains low levels of dissolved oxygen (DO) as a result of the heavy biological oxygen demand (BOD) and chemical oxygen demand (COD). Apart from this industrial wastes contain chemicals and heavy metals like arsenic, lead, mercury, cadmium and zinc, which are harmful to human health and ecosystem. When used for irrigation purposes, polluted water has serious impact on land productivity. Heavy concentration of chemical and metals in both surface and groundwater bodies cause serious damage to ecology of various river systems. The consequences of water pollution due to heavy discharge of industrial effluents are being witnessed by majority of the industrially booming towns in India. Surveys have been carried out in some of the industrial towns that show pollution of water, soil, and air. The impact of pollution is found even in food chain in some places (for a recent account see Down to Earth, 1998; Reddy, 1998). Assessing the cost of resource degradation and environmental pollution in the developing countries has not given much importance, more so in the case of industrial pollution.

Though there are lot of empirical studies on agricultural related environmental problems, such as soil degradation, wind and water erosion, only a few studies have dealt with environmental problems in agricultural sector due to industrial pollution. The difference is that the former problems are intra-sectoral while the later are inter-sectoral. This paper makes an attempt to study the environmental impact of water pollution on the rural communities in general and on agricultural production, human health, and livestock in particular. Some of the important issues in this regard are: a) linkages between the industrial development and changes in micro (local) environment, b) damage to crop and animal husbandry due to industrial pollution and, c) impact on health and sanitation in the rural communities.

These issues are studied in detail with the help of primary data collected from a pollution-affected village in Andhra Pradesh. This paper is organised in six sections. A review of studies on the impact of industrial pollution on agriculture and health is presented in the following section. A profile of the industrial pollution in the study region is presented in section three. Section four discusses the data used and the methodologies adopted in the study. Based on the data analysis, impact and valuation of the damages due to pollution are estimated in section five. And the last section narrates the failure and options in correcting the problem.

II Impact of Industrial Pollution: A Review

Here the review is focused on the impact of industrial pollution on agriculture and human health pertaining to developed countries, as there are no studies, to our knowledge at least, in the context of the developing countries.

a. water pollution and agriculture :

Rapid industrialisation has resulted in heavy discharges of toxic chemical effluents to various water sources like stream, river and tank causing serious damages to water quality and contamination of ground water. Agricultural production depends upon the quality of irrigation water. Pinock (as cited in Pearce, et. at, 1978) has analysed the effects of different levels of water quality on output and income for irrigated agriculture. Using the time series data, he studied three electrical conductivity's (EC) of irrigation water and its impact on crop yield and budgeted income; EC = 1.25 (1960), 1.44 (1980), 1.93 (2010). He estimated the damage for two points, one is for 1980 is $1350 for crop loss and other one is projected damage for 2010 is $854,679 for crop loss. The projected damage cannot be considered as it is because one is not sure of the future EC levels.

Vincent and Russel (as cited in Pearce, et. at, 1978) have presented a more comprehensive analysis of saline water damages in the Colorado River basin. These studies have examined the losses to municipal, industrial and agricultural sectors as well as the indirect economic losses to the regional economy. On this basis, they estimated the total damage cost for 1980s at around $26 – 27 million. Moore (as cited in Pearce, et. at, 1978) has argued that the total concentration of dissolved salts expressed in electro-conductivity has been found to be the most important single criteria of irrigation water quality. The results indicate that due to deterioration of water quality in the Colorado river at Imperial Dam from 1974 level of EC = 1.5 to the projected level for the year 2000 of EC = 2.0 would cause a decline in the returns to land and water of about 14% for Imperial Valley farmers. Further deterioration of water quality in the lower Colorado River to EC = 3.0 would cause a decline of about 26% in net returns. Kneese and Bower (as cited in Pearce, et. at, 1978), however, argued that although water quality deterioration is reflected in crop yields, the extent to which the crop yields are reduced is a function of interrelated factors including climate, soil types and farm management.

b. Water pollution and health effects :

Human health is one of the most important factors like any other factor for economic development to any economy. Above all, a healthy workforce is very much essential to the development of an economy. A healthy workforce requires a healthy environment, i.e., clean air, water, recreation, wilderness, etc. Pearce and Warford (1993) have argued that the most important and immediate consequences of environmental degradation in the developing world take the form of damage to human health. Further they argued that Diarrhea is a common occurrence in many developing countries where three million to five million cases are recorded every year. Each case is estimated to involve a loss of 3-5 working days, amounting to 9 billion working days lost in a single year.

It has been found that the developing countries are facing serious water borne diseases due to lack of safe drinking water. Walsh and Warren (as cited in Pearce, and warford, 1993) have estimated mortality and morbidity from water borne diseases in Africa, Latin America and Asia. According to them water borne diseases due to water pollution have definite impact on morbidity and mortality. And ultimately it has serious negative impact on economic activities in the form of loss of working days, deaths of trained workers, expenditure on hospitalisation etc. Besides, a number of attempts have been made to estimate the economic cost of health damage due to water pollution in developed countries. Pearce, et.al, (1978) have reviewed some of the studies conducted in the USA to estimate national health costs of polluted water. Outbreaks of the disease were monetarised on the basis of ten days-lost income and resource costs of a five-day stay in hospital. It was estimated that the unit social cost per case was $100 and that there were approximately 1million cases of Gastroenteritis per annum in the USA. In fact, two million working days are lost in the USA due to acute Gastroenteritis and Diarrhea at an average wage loss of $30 a day. It is estimated that the value of the 1000 deaths due to infection Hepatitis per year at around $100,000 per life.

Another attempt was made by Phantumvanit, (as cited in Jan, et. al, 1992) in Thailand to compare the damage cost due to water pollution and the abatement cost. He investigated the potential damage cost in order to compare them with the abatement cost of a pollution control program. He adopted direct questioning method (CVM) along with the available scientific findings. The relationship between the damage cost and the water quality were examined. It was concluded that treatment level had to be kept above 75% in order to maintain the River quality above 4mg/1 of dissolved oxygen above which no damage cost are assumed. At the macro level countries like Poland, Netherlands and Germany seem to have high environmental degradation costs. For instance, in Netherlands the estimated cost of pollution damage was 0.5-0.8 percent of GNP in 1986. Ethiopia has estimated the cost of deforestation as $300 million in 1983, or 6% of Ethiopia's GNP (Pearce and Warford, 1993).

As shown by Pearce and Warford (1993) the damage costs in the developing countries are higher than the developed countries. It clearly indicates that the environmental damage cost in developing countries approximates to 5% of their GNP. This is a serious threat to the sustainability of these economies, as many of these countries fall under the category of negative growth when these costs are incorporated in to their GNP. The exact estimation of damage cost depends upon the reliability of data relating to environmental damage. In developing countries it is very difficult to get exact information on various aspects of environmental damage.

Despite these uncertainties, it is confirmed that environmental deterioration damages the economies of both the rich and poor countries.

III The Setting:

For the purpose of the present study a village falling under the Patancheru industrial belt of Medak district of Andhra Pradesh has been selected. The village is badly effected by the industrial pollution, an environmental externality.

Anatomy of the Environmental Externality:

There are four major industrial areas in Ranga Reddy and Medak districts of Andhra Pradesh. These are a) Patancheru, b) Pashamylaram, c) Bollarum, and d) Kazipally. Among these industrial areas Patancheru is one of the oldest and most environmentally degraded industrial areas. Patancheru region houses some 80 firms, about half of them are chemical units, including lifesaving drugs. Major chemical and bulk drugs manufacturing units are located here, which generates significant quantities of hazardous waste. These wastes are not controlled effectively and are consequently being dumped along with municipal solid waste on vacant lands close to the factories or along roadsides. These hazardous waste dumpsites result in contamination of soils, surface and groundwater. A drive from Patancheru to Sangareddy is a nauseating experience, from visible and invisible sources. It is a health hazard for cattle roaming in and around the industrial waste. In fact, the burden of pollution on the environment has already crossed its assimilative capacity. The negligence on the part of policy makers can only be described as, environment forfeited for the sake of industrialisation, chemical consumption, and competitiveness in global chemical product markets.

Patancheru region is among the most unplanned industrial estates in Hyderabad, where there is no specific plan as such for establishing industrial units. Industrial units are established in a very unsystematic, haphazard and scattered manner. As a result, it is becoming very difficult to assess the environmental impact of a particular unit. For instance, if all the chemical industries are located in a particular area, then the impact assessment of the chemical industries could be easier, and accordingly the measures can be taken to reduce or to prevent the environmental damage. However, the situation in Patancheru is completely different because it is a cluster of less and more polluting industries.

Impact on Irrigation

Irrigation systems are the most affected due to the industrial pollution in Patancheru region. In Patancheru, at least 15 irrigation tanks are there. According to unofficial sources, all the 15 tanks have been completely polluted. However, officially (Sangareddy PCB) it is claimed that 5 irrigation tanks have been completely spoiled and rest of the tanks are partially affected. Among these Krishtareddypet and Gandiguddem tanks are highly polluted. But the farmers have no other option but to irrigate with polluted water. As a result, the productive lands are turning unproductive. The entire water bodies both ground and surface water is contaminated. The biological oxygen demand (BOD) level in the polluted water has already crossed the limit for drinking. The pollution control board of Sangareddy has tested various samples of polluted water of Patancheru industrial belt and found that dissolved oxygen of water body is 0 indicating that it is no longer suitable the species.

As far as agricultural lands are concerned, it is estimated (officially) that about 974 acres of agricultural land is affected severely in the Patancheru Mandal. In Patancheru region Paddy is the major (in some villages it is the only crop) crop, which gives employment to a sizable amount of agricultural workers. This indicates that the impact is in terms of loss of production (mainly paddy) and employment losses. Therefore, it is pertinent to examine the economic impact of industrial pollution on agriculture and the livelihoods of the rural communities.

Plight of the Rural Communities:

Air or water pollution or both have affected around 15 villages in this region. The most strident problem is of drinking water. As mentioned earlier in the Patancheru mandal both surface and groundwater are totally polluted. People are completely depending on the municipal drinking water supply. But the meager municipal water supplies force the villagers to depend on the contaminated water for the purposes other than drinking. Livestock is also forced to drink the polluted water and hence suffer from various diseases. Number of deaths is also reported in the village, apart from declining milk yields and fertility rates. This adds to the owes of the households.

The current situation in Patancheru is alarming. Due to the use of contaminated water, people are suffering from various water borne diseases like skin infection, fever, joint pain, etc. As there is no in-depth study on the impact of pollution on health of the people, it is difficult to estimate the exact costs of the problem. Adding these costs (health) will bring out the real costs borne by the households. Besides, these costs need to be added to the cost-benefit analysis of the polluting industries.

After a lot of protest from the villagers a common effluent treatment plant (CETP) has been established in the Patancheru industrial belt. The entire liquid waste of Patancheru industrial belt comes to the CETP for treatment. After treating the wastes it releases the water in to the nearby streams, which join the Manjira River. The villages, which are located on the streams and the river, are severely affected. For, the CEPT is not effective, as we see latter. Fish population in the streams and Manjira River is affected badly.

IV Data and Methodology

A village was selected to collect detailed information regarding the damage costs due to industrial pollution. Detailed household level information has been collected regarding the damages and losses due to pollution. Information was gathered with the help of a structured questionnaire and also through participatory rural appraisal (PRA) methods such as informal group discussions with the senior citizens of the village, transect walks and so on. A sample of fifty farmers was selected using probability proportionate sampling (PPS) with respect to the size of the holding (big, medium, small and marginal). The household survey was conducted during June 1999 (the rabi harvesting time.

Both direct and indirect techniques were used to collect the detailed information on various impacts of industrial pollution (on agriculture, on livestock, and on health). Direct approaches such as contingent valuation method (CVM) were used to collect the information on willingness to accept by asking the respondent directly to state the minimum amount of money he would be willing to accept as compensation for crop loss per acre per season in the context of an actual market situation. Indirect methods such as Effects on Production (EOP), Replacement Costs (RC), and Human capital (HC) approaches were used to estimate the damages and losses (crops, agricultural equipment and health).

a) The Effects on Production Approach (EOP) : The Effects on Production Approach principle states that an activity may affect the output, costs and profitability of producers through its effect on their environment. If there is a market for goods and services, the effects of environmental impact can be represented by the value of the change in output i.e. the reduced value of fish caught as a result of river pollution. EOP has also been used to trace the impact of such environmental changes as soil erosion, deforestation, wetland and reef destruction, and air and water pollution on agriculture, forestry, fisheries, power, public services and other sectors (Winpenny, 1991). In our study the impact of water pollution (irrigated water) on agricultural productivity has been determined, and annual losses the households are incurring have been estimated by putting actual current market prices. Similarly the loss due to decline in milk productivity has been estimated. This is carried out using the before and after method. As the pollution problem is recent (about 5 years) before and after method does not pose any serious problem of memory lapse. Moreover, since all the surrounding villages are equally effected by pollution it is difficult to use the 'with and without' method.

b) Replacement Costs (RC) : Replacement cost (RC) approach states that if the environment has already been damaged, in order to restore it to its original state the people have to spend some money. For example the victims of environmental damage replace their environment by moving away from the effected area. The costs, which the victims incur by moving to a clean environment, are called replacement costs. One of the techniques adopted in the replacement cost method is that of direct observation of actual spending on safeguards against environmental risks (Winpenny 1991 pp 48). In this study the replacement cost method has been adopted in order to estimate the costs of corrosion of agricultural equipment (repairing costs of machines) and damage costs of pump sets due to water pollution. Data pertaining to the damage costs is based on the households actual spending on repairs and replacement.

c) Human Capital (HC) : The human capital approach considers people as the economic capital and their earnings as return to investment. Environmental economics focuses on the impact on human health due to bad environmental condition, and the effect this has on the individuals and society's productive potential (Winpenny, 1991). Here the method would estimate the economic costs of illness of a productive human. Two variants of this can be taken into account while measuring economic costs of illness due to environmental factors, first, the loss of earnings (working days) lost due to illness and second, the cost of medical treatment. In out study, we have calculated the loss of productive time and annual expenditure on health care, and then arrived at the total economic value of illness. However, it may be noted that we have not taken any help of medical science or epidemiological data to correlate the illness with pollution. But, the laboratory tests of various water samples from the village suggest equivocally that there is enormous possibilities of water related diseases.

d) Contingent Valuation Methods (CVM) : CVM states that where the market is totally absent to obtain the actual value measure of benefits and costs of changes in environmental quality, the most straight forward way of assessing the benefits and costs would be simply to ask people their willingness to pay (WTP) and willingness to accept (WTA). CVM provides a way of tracing the demand curve for a commodity that cannot be revealed through market data (Murthy, et. al, 1999, pp217). The two concepts most widely used are willingness to pay for an environmental benefits, and willingness to accept compensation for loss of environmental quality. Despite all the credibility and popularity, CVM is not free from various criticisms (for critical reviews in the Indian context see Reddy, 1998 and Murthy, et. al, 1999). In the context of the present study, an attempt has been to minimise the various biases that creep in while conducting a CVM survey (for details on this see Reddy, 1998).

V Impact and Valuation of Industrial Pollution

Gandigudem village has been chosen for the case study. It is a village located 21 km to the northeast of Hyderabad, the capital of Andhra Pradesh. The village is a part of Medak district, Sultanpur Taluk, Patancheru Mandal. The area is bordered by Kazipalli a large industrial estate to the northeast, Bollarum a big industrial estate to the southeast, Sultanpur and Dayara mainly agricultural villages to the north west and southwest respectively.

Profile of the Village

This is an agriculturally dominant Village. Besides, most of the villagers go out for work to nearby industry (Bollarum) as casual labour during the off season, while marginal farmers go for work on a regular basis. The majority of the population belongs to the backward castes (Table 1). And around 90% people of the village are illiterate. Around 45.45 percent of cultivators belong to marginal farmers. However, large farmers own 31.34 percent of total area (Table 2).

Table - 1

Caste-wise distribution of households

Category	No of households	Main occupation
Backward caste	101	Cultivation & laborer
Muslims	08	Cultivation & laborer
General	01	Cultivation
Total	***110***	

Table - 2

Size-class distribution of land holdings

Category of cultivators (acres)	No. of HH	No. of HH sample	Area owned by sample HH (acres)	Average farm size (acres)
Big (>5)	12 (11)	5	42.00 (31)	8.4
Medium (4-5)	16 (15)	9	38.00 (28)	4.22
Small (2-4)	32 (29)	15	36.03 (27)	2.4
Marginal(0-2)	50 (45)	21	18.01 (13)	0.85
Total	***110 (100)***	***50***	***134.04 (100)***	***2.68***

Note: HH= households.

There is one big tank in the village, which irrigates about 710 acres of lands in four villages. As marginal cultivators dominate the village, they hardly can afford independent source of irrigation. The villagers also use the tank for other purposes such as bathing, washing, fishing, etc. Two decades ago, the entire village used to get drinking water from the tank and there was no tube-well in the village. During rainy season water comes to the tank from the hill areas of Kazipalli that provides water for the whole year. Mainly, it provides water for Rabi crops during summer, and for other uses. Some farmers have bore-wells for irrigation, which depend on the percolation from the tank. Generally, these wells are used as storage for irrigation and other purposes.

For the first time the villagers witnessed pollution in the tank water in 1993. After realizing that the tank water is getting polluted causing damage to agricultural production, some big and medium class cultivators tried for an alternative source, i.e., groundwater. However, the wells failed causing heavy losses to the farmers. Interestingly the well failure is due to pollution, which will be discussed latter. The main sources of pollution are, Kazipalli industrial belt that pollutes the tank water and the Bollarum industrial belt, which discharges the effluents directly as well as through the Common Effluent Treatment Plant (CETP). The Common Effluent Treatment Plant (CETP), which is situated at the entrance of the village, gets effluent from 20-25 factories. This treatment plant is treating the industrial effluent with a capacity of 0.25 MLD (million liters per day), but not up to the standards prescribed. When the water from CETP was tested, it is found that the COD (Chemical Oxygen Demand) is 651 mg/1, which is higher than the upper limit of COD (Chemical Oxygen Demand) of 3 mg/1. Similarly the other parameters of water are showing much higher levels of pollution (Table 3). Therefore, it is clear that the standard of treatment is not up to the mark. The so-called treated water is being injected into the ground through ditches and wells, which is contaminating the groundwater sources. A portion of the treated water is also being discharged in to the village land, which is directly seeping into the agricultural fields. On the other hand, the chemical industries of Kazipalli are letting out their effluent directly to the Gandigudem tank either through pipe or drains, which has contaminated both the surface and groundwater.

The industrialization in the area of Bollarum and Kazipalli started during mid 1980s. According to the villagers, they started realising the pollution in the early 1990s. Initially, the villagers thought that the industrial effluent would be beneficial for agricultural production, because they thought that the chemical water would provide more fertility to land. In 1991-92, the villagers witnessed a rapid change of color of tank water and at the same time they witnessed the death of fish. By 1994, it was observed that there were no fish left in the tank. In 1993-94, farmers got to know about the impact of pollution water on crops (they found empty husks without any rice). The impact of pollution on health has also become conspicuous as most of the villagers have started suffering from waterborne (pollution-related) diseases. The problem further escalated when the cattle became the victims of various diseases by drinking polluted water from tank and drains. Moreover, the village has been incurring heavy losses by loosing bullocks, cows, and other valuable cattle. By 1994-95, villagers realised that their groundwater has become salty and undrinkable. Since then the village became both socially and economically isolated from other parts of the region. For, the relatives from other villages stopped coming to the village due to the fear of pollution and nobody was coming forward to marry their daughters in the village. Their products like milk, rice remain unsold or sold at low rates in the market.

Impact of Pollution

The impact of pollution has been realized in all aspects of the village life. However, we have taken three impacts for in-depth analysis. These are a) impact on health, b) impact on agricultural activities, and d) impact on livestock. Before analyzing all the three impacts, the extent of water pollution, which is at the root of all the three impacts, has been analysed. For this purpose, water samples from different sources have been tested.

Water sources (both ground and surface water) have been badly affected by pollution. Water samples were collected in sterilized bottle of one liter each from different sources such as bore-wells, CETP and tank. The tests indicate that almost all the parameters are in excess of normal range (Table 3). Sample-I and II have been collected from two bore-wells in different parts of the village. Sample-III has been collected from the tank, and sample –IV from the CETP (Common Effluent

Treatment Plant) of Bollarum. The main purpose of testing the treated water of CETP is to know the standard of treatment. For, the treatment plant is either releasing the treated water to the village land or injecting into the ground through pipe or well. It is surprising to note that the water from CETP is equally, if not more, polluted. This indicates that the industrial effluents are not treated properly or the standard of treatment is not up to the mark resulting in contamination of groundwater and death of cattle. The death of cattle and serious diseases could be attributed to the content of poisonous metal, i.e. arsenic at 2.0 mg/l as against the permissible level of 0.05 mg/l).

Table - 3

Results of water sample tested showing concentration of various water parameters and its normal range (acceptable range)

Parameters	Sample I	Sample II	Sample III	Sample IV
PH	6.6 (7.0-8.5)	7.6	6.8	7.4
EC mho	7210 (750)	6000	4870	17780
TDS mg/1	4326 (500)	3002	2922	10668
Chloride mg/1	504 (200)	420	594	1392
Sulphates mg/1	220 (200)	250	359	732
Phosphates mg/1	0.025	0.020	0.25	3.0
COD mg/1	38 (3)	50	217	651
BOD mg/1	14 (3)	20	76	251
Calcium mg/1	315 (75.0)	500	261	553
Magnesium mg/1	151(30.0)	180	129	388
Total hardness mg/1	1541 (100)	1269	1199	2998
Alkanity mg/1	460(75)	480	380	1000
Arsenic mg/1	0.2(0.05)	0.1	0.75	2.0

Note: Central Laboratory, Andhra Pradesh Pollution Control Board, Hyderabad conducted Tests.

Sample I = bore-well – I; Sample II = bore-well – II; Sample III = tank water; Sample IV = CETP water.

TDS = Total Dissolved Solids, EC = Electrical Conductivity, COD = Chemical Oxygen Demand, BOD = Biological Oxygen Demand.

Figures in brackets indicate Normal range of Parameters.

When these parameters are compared with the crop responses for irrigation water (Table 4) with different concentration of salinity, one can visualise the impact on crop productivity in the village. Though there are 5 deep tube-wells in the village, not a single tube-well is suitable for drinking water. The village is totally dependent on the municipality drinking water supply. Municipality was started providing piped water only recently. Prior to that villagers were drinking contaminated water resulting in severe health problems.

Table - 4

Crop responses for irrigation water with different salinity

Crop responses	TDS (mg/1)	EC (mho)
1. Water for which no detrimental effects will usually be noticed	upto 500	Upto 750
2. Water which can have detrimental effects on sensitive crops.	500-1000	750-1500
3. Water that may have adverse effect on many crops.	1000-2000	1500-3000
4. Water that can be used only for salt tolerant plants.	2000-5000	7000-7500

Note: TDS = Total Dissolved Solids, EC = Electrical Conductivity.

Source: Goel P.K, Sharma K.P (1996).

a) Impact on Health:

The entire village has been suffering from various diseases arising out of water pollution. However, it was observed that most of the diseases are water-borne such as skin infection, teeth corrosion, joint pains, loss of appetite, defective vision, fever, abdominal pain, respiratory diseases, and diarrhea, etc. Apart from that general muscular weakness, immature growth, chronic cold, and cough in the middle aged and children are noticed in the village. Majority of complaints have come about the problems regarding lung diseases and extreme weakness .It is found that around 7 people in the village have got paralyzed due to drinking of contaminated water. This has led to severe psychological and economic pressure on the families concerned. People get exposed to the toxic chemical water while working in the farm, taking bath and washing clothes. This causes serious health problems including loss of hair for women.

The most important feature of health problem due to pollution is that women are the worst affected (Table 5). The percentage of effected females in each household is higher. This is because women do the entire household work with contaminated water like washing, cleaning, etc. The average number of days sick and unable to work per household is about 50 in a year. This indicates the loss of income and expenditure on health care. Across the size classes the incidence of sickness is higher in the case of large farmers, while the number of working days lost due to sickness is higher among small cultivators. Similarly the number of visits to doctors and expenditure on health before and after pollution reveal substantial increases. The expenditure on health depends on two factors i.e. (a) the severity of diseases and (b) the economic condition of the family. The marginal farmer's average visits to doctors are about 30 per annum and their medical expenditure is Rs. 4476/-. However, in case of small farmers the average visits to doctors is about 26 and their medical expenditure is Rs.6733. Small farmers are spending more money per visit to doctor, which is perhaps due to their better affordability. When expenditure is directly related to quality of treatment, frequency of visits to doctor would naturally come down.

We have estimated the total expenditure on health due to pollution. The average expenditure on health per household is calculated on the basis of loss of working days due to illness and expenditure incurred to cure the diseases. The average wage losses due to sickness is estimated using the daily market wage rate i.e. Rs.50. Accordingly, the average loss per household is Rs.3695. Add the medical expenditure to this, then the average loss per household due to health impact works out to be about Rs.9366 per annum.

b) Impact on Livestock.

Livestock is one of the main sources of income in rural areas. Since all the local water sources are polluted, livestock in the village are also facing serious health problems. In the absence of sufficient municipal water supplies, livestock are forced to depend on polluted water and graze on contaminated grasses. It was reported by the villagers that around 338 cattle have died due to drinking polluted water during the last 6 years (Table 7). Majority of the cattle is becoming sick over the years. Another serious problem observed in the village is that some cows have lost their reproductive capacity. Reduction in milk productivity of buffaloes and cows is also reported. As a result of grazing contaminated grasses the quality of dung has been reduced to unusable level. Due to the fear of further deaths, people have started selling their cattle at a very cheap rate.

Table - 5

Impact of industrial pollution on human health

No. of people effected	Big Cultivators (5)	Medium Cultivators (9)	Small Cultivators (15)	Marginal Cultivators (21)	All
Total	26(56.52)	26(41.26)	65(52.4)	5(41.13)	182 (46.57)
-male	15(51.72)	12(33.33)	34(48.57)	29(32.95)	90 (40.35)
-female	11(64.70)	14(51.85)	31(57.40)	36(51.52)	92 (54.76)
Average No. of days sick/HH/ year	60	54.4	47	55	52.98
Average No. of daysunable to work/HH/year	60.8	76.33	78	71.9	73.89
Wage losses/ HH/year (A)	3040	3816.5	3900	3595	3694.5
Average No. of visits to doctor/ HH/year Before 1992					
Now	50.12	30.22	26.6	30.09	31.03
Average amount spent on (Rs.) medical/ HH Before pollution:					
After pollution:(B)	6040	6488.8	6733	4476	5671.8
Total Losses (A+B)	***9080***	***10305***	***10633***	***8071***	***9366***

Note: figure in bracket is average per Household, HH = household.

As a consequence of the impact of pollution on livestock, there is a drastic change in the composition and holding of livestock before and after pollution. The change could be attributed to either the livestock have died by drinking polluted water or the people would have sold their cattle on account of fear of death. The percentage decline in livestock holdings due to pollution seems to be very high in case of big and small farmers, as far as the holding of ox, and buffaloes are concerned. On the other hand, the percentage of total cattle affected in case of marginal farmers is the highest, i.e., 76.25 (Table 6). This indicates that the marginal farmers are badly hit by pollution. In fact, now farmers depend more on tractor to plough their land rather than keeping/buying bullocks, because of unbearable risks of death.

Table - 6
Percentage of Decline in Livestock Holdings Due to Pollution in the sample households

Cultivators	Buffaloes	Ox	Cow	Goat	Sheep
Big cultivators	52.38	54.54	0	-	0
Medium cultivators	48.27	31.81	25	0	75
Small cultivators	41.17	53.84	78.57	38.96	14.28
Marginal cultivators	39.34	29.41	66.66	28.84	-
All	***42.86***	***39.69***	***56.06***	***23.8***	***17.8***

c) Impact on Agriculture:

All the cultivable land (250 acres) has been severely affected by soil degradation resulting in drastic decline in agricultural productivity. The decline in agricultural productivity can be solely attributed to irrigated water pollution (tank and bore-well). Electrical conductivity (EC) parameter of irrigation water is considered as the main indicator of irrigation water quality (Pearce, et. al, 1978). Electrical conductivity conveys the intensity of salinity of water bodies. The results clearly indicate that the concentration of salinity both in tank and bore-well water is high, because both the water bodies (bore-well and tank) have contained high level of electrical conductivity (7210 mg/1 and 6000mg/1 for bore-well water and 4870 mg/1 for tank water).

Table - 7

Impacts of pollution on livestock.

	Big cultivators	Medium cultivators	Small cultivators	Marginal cultivators	All
% of cattle affected	65.90	69.56	60.28	76.25	67.99
No. Cattle died:	38	54	71	175	338
Cost (Rs.):	1,22,000	1,22,000	1,58,400	3,16,000	718,400
Milk productivity (ltrs/cattle).					
Before pollution:	4.6	4	2.01	1.9	2.5
After pollution:	1.6	1.2	0.6	0.6	0.8
Medical expenditure on cattle per HH (Rs/ annum).					
Before pollution:	0	0	0	0	0
After pollution:	1,340	1,088	533	1,585	1,155

Note: HH = household.

Table - 8

Estimation of damage costs imposed on Agricultural activities due to pollution

	Big cultivators	Medium cultivators	Small cultivators	Marginal cultivators	All
Pump sets damaged.					
Number:	5	7	3	8	23
Cost(Rs.):	50,000	60,000	25,000	52,000	187,000 (623)
Expenditure on tractor due to loss of bullocks (Rs.)	0	12,000	72,000	12,000	96,000 (320)
Amount of land uncultivable (acres)	0	7	7	5.20	19.20
Repairing costs of machines per HH (Rs.)	12,000	5,600	16,850	46,000	80,450 (268)

Note: HH = household; Figures in brackets indicate per annum per household losses.

Apart from the decline in agricultural productivity, the polluted water has imposed enormous costs on various agricultural activities, like corrosion of agricultural equipment, damage of pump sets, repairing costs of machines, etc (Table 8). The damage of pump sets has become a serious concern for the villagers, as most of the pump sets were bought with loans from banks. This has led to farmer's indebtedness. Irrigation water containing detergents washout the lubricants from oscillates and pumps. And an excessive amount of suspended solids in the water requires frequent cleaning of filters and nozzles (Pearce, et. al., 1978).
At least 23 pump sets have been damaged during the past 6 years at a total cost of around Rs 187,000. And total-repairing costs are calculated as Rs 80,450/ (Table 8). These costs are incurred during the period of six years. Accordingly per annum costs of repairing and damage of pump sets have been calculated. The average total cost of agricultural activities, including expenditure on tractor due to loss of bullocks per annum per household is Rs 1211/. The expenditure on tractor due to loss of bullocks are mainly incurred by the medium, small, and marginal cultivators. For, the big cultivators either they own tractors or they are having more pairs of bullocks to plough their land.

The changes in the area under cultivation and yield per acre before and after pollution indicate that the losses are substantial in terms of yield, yield loss is about 76 percent as against 14 percent of area loss (Table 9). Across the farmers it is the marginal farmers who suffer the maximum losses in terms of area (33 %) as well as yield (80%). Area loss to marginal farmers is substantial when compared to other categories, as they do not have access to well irrigation. The loss of income is estimated on the basis of the differences between average income earned by the households before pollution and after pollution. The household income is determined on the basis of market prices of paddy. The market value of one bag (70 kgs) paddy is Rs 500/ approximately. The average loss of income due to pollution is estimated at Rs 9627/ per acre. The average losses incurred by the cultivators in the form of pump sets damaged, repairing costs of pump sets and electric motors, and expenditure on tractor due to loss of bullocks is around Rs 1211/ per acre. Thus, the total loss on agriculture amounts to Rs 10828/ per acre. If these costs are converted on the basis of households they work out to be about Rs. 36085 per annum i.e., including agriculture, livestock and health losses (Table 10).

If the average loss per sample household is generalized then the total loss per annum to the village will be to the tune of Rs. 3969350 (Rs 36085 5 110). Similarly the total loss to the village from the last six years can be calculated. The average loss to the crops is calculated for one seasons (Rabi) only, though farmers cultivate two crops in a year. For, majority of the farmers expressed that the Kharif is highly uncertain, as it is totally dependent on monsoon. Large area of land remains flooded in rainy season. Looking at this uncertainty over the kharif season, the loss to crops in kharif season is not taken into account.

Table - 9

Impact of pollution on agricultural productivity and area under cultivation.

Cultivators	Area cultivated (in acres)		Average yield per acre per season in terms of bags		Average loss of paddy per acre due to pollution (In bags). (In Rs.)	
	B.P	A.P	B.P	A.P		
Big	42.00	42.00	22.4	5.4	17	8500
Medium	38.00	31.00	24.5	5.3	19.2	9599
Small	36.03	29.03	24.9	6.8	17.6	8799
Marginal	18.01	12.20	26.3	5.4	20.9	10499
All	***134.04***	***114.23***	***25.16***	***5.8***	***19.25***	***9627***

Note: 1. 1 bag = 70 Kgs.

2. B.P. = Before Pollution (1992); A.P = After Pollution (now 1999).

Table - 10

Total average loss per household per annum

Loss on health	Rs 9,379/
Loss on livestock	Rs 3,550/
Loss on agriculture	Rs 23156/
Total	***Rs 36085/***

The above analysis is based on pre and post pollution scenarios where the pre pollution figures are subject to the problems associated with recall and memory lapse of the farmers. In order to cross check this discrepancy we have estimated a production function using quality of water as one of the independent variables. For this purpose we have used the data from 21 plots of paddy where they use either bore-well or tank for irrigation

Since our analysis suggests that bore-well water has high electrical conductivity (EC) than tank water, the impact of quality of water can be measured through using source of irrigation as an independent variable (dummy variable). The specification is as follows:

$$Y = a + X_1 + X_2 + X_3 + X_4$$

Where,

Y = yield per acre in Rs.

X_1= Capital costs (seeds, manure, fertilizer)

X_2= Labor costs (labor)

X_3=source (quality) of irrigation (“0” for bore-well and “1” for tank)

X_4=Farm size

Theoretically X_1 and X_2 will have positive impact on yield while farm size (X_4) is expected to have an inverse relationship with yield per acre. On the other hand, the dummy variable will have positive impact on yield as one moves from more polluted (well) water to less polluted (tank) water the per acre yield will increase. The equation is estimated using the OLS method. The following specification is selected from a number of permutations and combinations that were tried.

$$\underset{(856.51)}{Y= 1699.802} + \underset{(0.51)}{0.400881X_1} + \underset{(0.49)}{0.176556X_2} + \underset{(362.96)}{834.7363\, X^{**}_3} + \underset{(97.18)}{112.9018\, X_4}$$

R^2 = 0.31, N= 21, D.F = 16

Note: Figure in brackets is standard error.

** Significant at 5 percent level.

The estimates indicate that quality of water is the only factor influencing the productivity changes. The variable X_3 turned out significant and positive, which support our argument that the tank (less polluted) water is giving more yields than the bore-well (more polluted) irrigation water. The magnitude of changes is about Rs 800, i.e. a shift from tank irrigation to bore well irrigation (a 25 % increase in EC) will result in loss of Rs 800 per acre per annum.

Households Willingness to Accept (WTA) for Pollution Damages:
It is a direct method to estimate the damage costs by asking the respondents to state how much they are willing to accept so that the industry can continue to pollute. The respondent is asked about the willingness to accept for the damage costs to per acre land per season. Due to some practical difficulties we could not adopt the bidding method. Here we have referred only to the compensation for crop losses, as the farmers are clearer about it.

The average willingness to accept is consistent with their losses of crops in case of three classes of cultivators, i.e. big, medium, and small (Table 11). But in case of marginal cultivators the WTA is understated. The reason could be that the marginal farmers are very much dependent on daily wages. Since the marginal farmers are having very smallholdings of land (0.85 acres), they do not give much importance to cultivation rather they go for daily labour. They compensate their losses through wage earnings. Hence, the perceived crop loss due to pollution for this class of farmers could be on the lower side[2] . The differences between actual loss and WTP are conspicuous at the individual level (Table 12). However, these differences are ironed out when averages are taken. Thus, the valuation of damage costs due to pollution confirms that there has been severe damage to village community due to industrial pollution. This calls for urgent policy measures, which could be capable of solving the problems of industrial pollution.

Table - 11

Average willingness to Accept per acre per season (Rs)

	WTA	Actual Damage
Big cultivators	9000/	8500
Medium cultivators	9111/	9599
Small cultivators	8933/	8799
Marginal cultivators	6714/	10499
All	***8040/***	***9627***

Table - 12

Number of Cultivators Showing Loss (in Rs.) and WTA Per Acre.

Cultivators		Below 6000	6000-7000	7000-8000	8000-9000	Above 9000
Big	Loss	2 (5250)	0	0	1 (8500)	2 (11750)
	WTA	0	1 (6000)	2 (8500)	2 (11000)	
Medium	Loss	0	2 (6500)	1 (7500)	1 (9000)	5 (11400)
	WTA	1 (5000)	0	0	3 (8500)	5 (10300)
Small	Loss	1 (5000)	2 (6250)	1 (7500)	0	11 (12272)
	WTA	1 (5000)	0	3 (7000)	2 (8500)	9 (11000)
Marginal	Loss	2 (5250)	0	1 (7500)	4 (8327)	14 (12357)
	WTA	7 (4714)	2 (6000)	1 (7000)	1 (9000)	10 (10000)
All	***Loss***	***3 (5200)***	***4 (6375)***	***3 (7500)***	***6 (8468)***	***32 (12140)***
	WTA	***9 (4777)***	***3 (6000)***	***4 (7000)***	***8 (8562)***	***26 (10480)***

Note: Figure in bracket is average loss.

VI Failed Options

The pollution from the industries that produce some of the life saving drugs has turned the surrounding villages into virtual killing fields. The way in which the environmental externalities have occurred can mainly be attributed to three important failures i.e., market failure, policy failure and institutional failure. Under these circumstances to what extent the two main stream economic approaches, which are widely known to be effective in tackling environmental problems such as Pigouvian approach and Coaseian approach are applicable need to be tested. What follows is an attempt to see the current environmental problems in the study area through the light of three above failures.

i) Market Failure :

The environmental problems arise in two forms : first, the unacceptable level of water pollution has resulted in negative externalities affecting the rural communities. These costs are not reflected in the price of industrial products. That is, markets failed to internalise the externalities. Another form of market failure is the absence of a pricing mechanism for industrial pollution between the victims and the polluters. The price mechanism can work effectively provided the property rights are well defined and enforced. But in the present case, the tank, which gets polluted, is a common property resource (CPR). Both the cultivators and industries are using it. In case the village community has clear rights on tank, a bargaining could be made between the victims and polluters. This is the main principle in Coaseian approach to internalise the externality at zero transaction cost. In reality, the victims are more and to bring them into a bargaining position would involve some costs violating the zero transaction cost assumption of Coaseian approach.

Regarding the groundwater pollution, the Common Effluent Treatment Plant (CETP) is the main culprit, as the effluent treatment is not proper. These untreated effluent waters are either pumped into ground or left in the open field resulting in the contamination of groundwater. Unlike tank water, the property rights (though de facto) in groundwater are clear and individual based and hence transaction costs of organisation are zero. But, there were no instances of bargaining because it is difficult to identify the source of pollution. More importantly, the existing policy or legal environment is not conducive for such bargaining. For, everybody knows that CETP is the main polluter.

ii) Policy Failure :

When market mechanism fails to address certain environmental externalities, a third party intervention could help in minimising the externalities. This is the so called the interventionist approach or Pigouvian approach which suggest the state to intervene with various effective policies. The Pigouvian approach to negative externalities would need a strong regulatory system in order to control and regulate the pollution. In Andhra Pradesh the State Pollution Control Board (PCB) has acquired more powers after the enactment of the Environmental Protection Act 1986. According to this act, the PCB has the right to order for the closure of the industries violating its norms. And, before an industry is established, it is obligatory on its part to take license from the PCB that the industry is well equipped to handle the effluent it generates. Though these sound effective on paper, in reality political interventions and legal bottlenecks hinder the implementation. Initially, when industries were set up, in Bollarum and Kazipalli, the problems of pollution were sidelined in order to promote rapid industrialisation.

The Sangareddy PCB is a regional office, which is responsible for the area of Kazipalli and Bollarum. The villagers have complained number of times regarding the loss of crops, loss of cattle, and pollution of tank and tube well water. In response to these complaints, the officials visited the village and surveyed the area. They took various water samples and got tested. According to the villagers, this has become a routine for PCB, and no action was initiated against the industries or the CETP. There seems, according to the villagers, to be a nexus between the industrialists and the PCB officials. Industrialists also use lobbying tactics to make the policy ineffective.

Another failure is observed with regard to the judicial systems. In 1994, the villagers blocked the Patancheru highway to Medak district and brought the district judge to visit the village. After seeing the situation, the judge promised the villagers to bring the issue to the court. A case was filed in the Supreme Court. The Supreme Court ordered that a report regarding the damage due to pollution should be submitted and also ordered that even one drop of effluence cannot be discharged into the village. Since then the judge is coming to the village to assess the damage every month and talk to the people. But, despite the Supreme Court order, industries continuing to discharge effluent into the village land and tank, as is evident from our study. Therefore, neither social nor environmental issues can be tackled merely by passing laws. The law needs to be implemented in its right perspective. Whether the law is adequate to tackle environmental issues or not and its effectiveness are entirely dependent on the political will of the authorities, who implement it.

iii) Institutional Failures :

In the wake of market and policy failure, it is always felt that institutional approach is an alternative to tackle environmental problems. Collective action of all the relevant agents or victims is one such solution. Community action is very much needed in order to have the bargaining capacity or to force the regulatory bodies to respond to their problems. In our study, community action though present was not effective. Under the leadership of a local NGO protests in the form of Dhahran (mass squatting in front of the state Secretariat) and Rash Rook (blocking roads) were organized. However, it did not give any positive results rather the villagers were lathi charged and arrested. Neither industries nor PCB responded to the protests. Then people became militant and attacked the industries. Since then the industries stopped discharging their effluent during daytime into the village instead they started discharging during the night. In fact, twice the villagers caught the persons during the nighttime while discharging the effluent in to the village and beat them up severely. After that incident the industries were closed down for three to four days and started again.

Despite all these actions, the community did not succeed in influencing either industries or regulatory authorities in finding a permanent solution to the problem. According to the villagers, the industrialists are having high level political connections to influence the matter in their favour. The main reason behind the failure of collective action is the absence of effective leadership among the villagers. More importantly, there is no coordination among the villages that are effected by pollution. If these villages are brought together under the guidance of a committed leader or NGO, this issue has the potential for a mass movement. Unfortunately, the present situation in every village is that of frustration.

Nevertheless, the process of mediation is going on between the villagers and the industries through the district judge who is coming frequently to the village. The industries have agreed to pay compensation for the loss of crops only. The amount of compensation is only Rs.1000/- per acre per year, which is not acceptable to the villagers. In fact, in our study it is estimated that the average losses per acre per season are between Rs.6000/- and Rs.10, 000/-.

However, the compensation cannot solve the problem. Here the compensation means giving the right to pollute. Besides, if the compensation does not reflect the real costs (including health effects) then there is no incentive to internalise the externalities. On the contrary, the incentive is to pollute more. Looking at the health impact of the pollution any amount of compensation less than the actual costs would not suffice to address the problem. A close look at the economics of pollution mitigating technologies will help in arriving at the right amount of compensation, which will work as an incentive to adopt the technologies. Another popular option is shifting of the industries, which is only a short run solution. Therefore, strict regulation on the industries to adopt pollution-mitigating technologies fostered with a compensation package would go a long way in cleaning up the mess. Of course, all this calls for a change in the attitude of the policy makers.

Notes :

[2] This aspect is further cross-checked by estimating the WTA function with OLS method. The functional form is:

$$Y = a + X1 + X2 + X3 + X4 + X5$$

Where, Y= WTP; X1= Farm size; X2= Household size; X3= annual income of the household; losses in rupees per season due to cop failure and X5= number of workers in each household.

The estimated equation is:

$$Y = 7498.1 + 208.4X1 + 130.6X2 + 0.01X3 + 0.04X4 - 352.8X5^{**}$$

(2175) (154) (122) (0.03) (0.12) (144)

(figures in brackets are standard errors)

$R2 = 0.18$; $N = 50$; D. F = 44

Only one variable i.e., X5 is significant and negatively associated with WTA. That is, higher the number of workers in the household lower the WTA. This supports our proposition that marginal farmers, who depend more on labour, are having low WTA.

References :

Coase, R. H (1960): "The problem of social cost", *Journal of Law and Economics,* Vol-3, Oct, pp-1-44.

Down to Earth : Science and Environment Fortnightly Magazine, Vol-7, No-13, Nov-30, pp. 26-36.

EPTRI (1996) : *Status of Environment of Hyderabad Urban Areas Agglomeration,* Research Report, Andhra Pradesh Pollution Control Board.

Goel, P. K, and K.P Sharma (1996): *Environmental Guidelines and Standards in India,*Technoscience Publication, Jaipur.

Jan, B., Maler, K., Unema, L., (1992): *Environment and development: An Economic Approach,* Kluwer Academic Publisher, London.

Murty, M. N., A.J. James, and Smita Misra (1999): *Economics of Water Pollution: The Indian Experience,* Oxford University Press, New Delhi.

Pearce, D. W, et al (1978): *The Valuation of Social Costs,* George Allen & UNWIN, London.

Pearce, D. W., and J.J. Warford (1993): *World Without End: Economics, Environment and Sustainable Development,* Oxford University Press, Oxford.

Reddy, V. Ratna (1995): "Environment and Sustainable Agricultural Development: Conflicts and Contradictions", *Economic and Political Weekly*, Vol. XXX, No.12, Mar, pp-A-21.

Reddy, V. Ratna. (1998): "User Valuation of Renewable Natural Resources: Some Methodological Issues", *Quarterly Journal of International Agriculture*, Vol-37, No-1, Jan-Mar, pp-42-69.

Sinha, A.K et al (1989): *Water Pollution Conservation and Management,* ITRC, Lucknow.

Winpenny, J.J. (1991): *Values for the Environment: A Guide to Economic Appraisal,* HMSO, London.