Impact of Water Pollution and Degree of Treatability - Valuation for Ecosystem changes

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Abstract*: The billions of species on our planet including humans interact with one another in many ways. These interactions among the species are what define ecosystem. Ecosystem in turn, provides many services from which humans benefit. Ecosystem services are the transformation of a set of natural assets i.e. soil, plants, animals, air and water into things that sustains life in the biosphere. Human beings need natural resources like water, sunlight, coal, minerals, and natural gas. These are imperative for sustaining the life and are produced by earth's natural process. Increasing population and over exploitation of the natural resources pave way for depletion and degradation of ecosystem. The water of even the healthiest rivers and lakes is not absolutely pure. All water contains many naturally occurring substances* - *mainly bicarbonates, sulphates, sodium, chlorides, calcium, magnesium, and potassium. They reach the surface and groundwater from: soil, geologic formations and terrain in the catchment area (river basin); surrounding vegetation and wildlife; precipitation and runoff from adjacent land; biological, physical and chemical processes in the water; human activities in the region. In this paper an attempt has been made to assess the impact of water pollution on degree of treatability of water and Valuation for ecosystem changes. This paper emphasised on the functional relationship between the raw water and treated water. This paper highlights about the economic benefits of protecting the reservoir from runoff, interms of reduced purification costs.*

Key Words: Ecosystem, Valuation, Catchment, Economic benefits

Introduction

The Indian natural resources are sufficient to satisfy the needs of the citizen not their greed's stated by the father of Nation Mahatma Gandhi. But increasing population, improper and accelerated use of natural resources depicts it is not even sufficient for the needs. Although agriculture provides the food and nutrition, the majority of necessary natural resources obtained from the environment cannot be formed, grown, cultured or replenished at the rate of their utilisation. The maximum number of byproducts can be produced from wheat and rice in factories but basically wheat and rice are cultivated on mother earth. Similarly the mineral water processed, packed and sealed in factory but basically the water is the natural resource and its budgeting depends on hydrologic cycle of earth's natural process. Therefore, managing and using existing natural resources in a sustainable way is a key priority of the whole world.

Ecosystem valuation is the pricing or assessment of economic capital asset value to a living ecosystem. Economic value is one of many possible ways to define and measure value. Economic values are useful to consider when making economic choices, choices that involve tradeoffs in allocating resources. Measure of economic value depends upon what market demands, it is based on what people want, what are their preferences. Theory of economic valuation is based on individual preferences and choices. An individual decides what he or she wants, prefers with some constraints like income, available time etc. Market price depends on the demand of that particular good. Generally law of demand prevails in the open market. Increased price of any item/good reduces the purchasing capacity. By relating the quantity demanded and the price of a good, one can estimate the demand function for that good. i.e., demand curve (figure 1), the graphical representation of the demand function.

The resource allocation decisions are based on economic values, because it measures the net economic benefit from a good or service. The economic benefit to individuals is often measured by consumer surplus. This is graphically represented (figure 1) by the area under the demand curve for a good, above its price.

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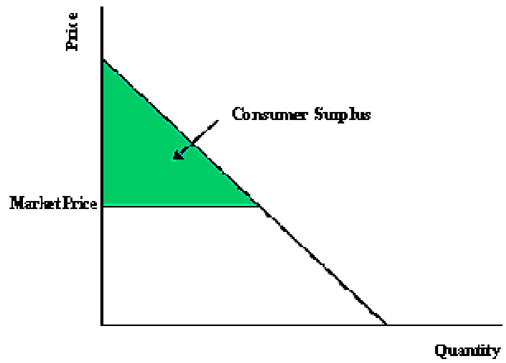


Figure 1. The Demand Curve

The economic benefit to individuals, or consumer surplus, received from a good will change if its price or quality changes. If producers receive a higher price than the minimum price they would sell their output for, they receive a benefit from the sale—the producer surplus (figure 2). Thus, benefits to producers are similar to benefits to consumers; because they measure the gains to the producer from receiving a price higher than the price they would have been willing to sell the good.

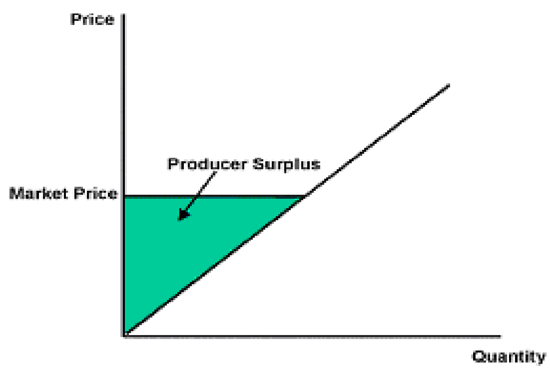


Figure 2. The Supply and Producer Surplus

When measuring economic benefits of a policy that affects an ecosystem, economists measure the total net economic benefit. This is the sum of consumer surplus plus producer surplus, less any costs associated with the policy. To ascertain a value to an ecosystem is a very difficult and controversial task. But this is very helpful in justifying the priority of any project, which will be useful in protecting or restoring ecosystems and their services. Ecosystem functions are the physical, chemical, and biological processes that contribute to the self-maintenance of an ecosystem. Functions are provision of wildlife habitat, carbon cycling, or the trapping of nutrients. Thus, the processes, or functions, that occur within them, can characterize ecosystems, such as wetlands, forests, or estuaries.

Ecosystem services are the beneficial outcomes, for the natural environment or people that result from ecosystem functions. Some examples of ecosystem services are support of the food chain, harvesting of animals or plants, and the provision of clean water or scenic views. In order for an ecosystem to provide services to humans, some interaction with, or at least some appreciation by, humans is required. Thus, functions of ecosystems are value-neutral, while their services have value to society.

Necessity of Ecosystem Valuation

- To justify and decide how to allocate public spending on conservation, preservation, or restoration initiatives.
- To compare the benefits of different projects.
- To prioritize conservation or restoration projects.

Ecosystem values are measures of how important ecosystem services are to people – what they are worth. Economists measure the value of ecosystem services to people by estimating the amount people are willing to pay to preserve or enhance the services. However, this is not always straightforward, for a variety of reasons.

Most importantly, while some services of ecosystems, like fish or lumber, are bought and sold in markets, many ecosystem services, like a day of wildlife viewing or a view of the ocean, are not traded in markets. Thus, people do not pay directly for many ecosystem services. Additionally, because people are not familiar with purchasing such goods, their willingness to pay may not be clearly defined. However, this does not mean that ecosystems or their services have no value, or cannot be valued in monetary terms.

It is not necessary for ecosystem services to be bought and sold in markets in order to measure their value in monetary terms. What is required is a measure of how much purchasing power people are willing to give up to get the service of the ecosystem, or how much people would need to be paid in order to give it up, if they were asked to make a choice similar to one they would make in a market and their services.

Types of Values

Economists classify ecosystem values into several types. The two main categories are use values and non-use values. Whereas use values are based on actual use of the environment, non-use values are values that are not associated with actual use, or even an option to use, an ecosystem or its services.

Thus, use value is defined as the value derived from the actual use of a good or service, such as hunting, fishing, bird watching, or hiking. Use values may also include indirect uses. For example, a Himalayan hill stations area provides direct use values to the people who visit the area. Other people might enjoy watching a television show about the area and its wildlife, thus receiving indirect use values. People may also receive indirect use values from an input that helps to produce something else that people use directly. For example, the lower organisms on the aquatic food chain provide indirect use values to recreational anglers who catch the fish that eat them.

Option value is the value that people place on having the option to enjoy something in the future, although they may not currently use it. Thus, it is a type of use value. For example, a person may hope to visit the a Himalayan hill stations sometime in the future, and thus would be willing to pay something to preserve the area in order to maintain that option.

Similarly, bequest value is the value that people place on knowing that future generations will have the option to enjoy something. Thus, bequest value is measured by peoples' willingness to pay to preserve the natural environment for future generations. For example, a person may be willing to pay to protect the Alaskan wilderness area so that future generations will have the opportunity to enjoy it.

Non-use values, also referred to as "passive use" values, are values that are not associated with actual use, or even the option to use a good or service. Existence value is the non-use value that people place on simply knowing that something exists, even if they will never see it or uses it. For example, a person might be willing to pay to protect the Himalayan hill stations, even though he or she never expects or even wants to go there, but simply because he or she values the fact that it exists.

It is clear that a single person may benefit in more than one way from the same ecosystem. Thus, total economic value is the sum of all the relevant use and non-use values for a good or service. There are three generally accepted approaches to estimating monetary values of ecosystem services. Each approach includes several methods. Some ecosystem or environmental services, like aesthetic views or many recreational experiences, may not be directly bought and sold in markets. However, the prices people are willing to pay in markets for related goods can be used to estimate their values. For example, people often pay a higher price for a home with a view of the ocean, or will take the time to travel to a special spot for fishing or bird watching. These kinds of expenditures can be used to place a lower bound on the value of the view or the recreational experience. The methods are Market Price Method, Productivity Method, Hedonic Pricing Method, and Travel Cost Method

Productivity Method

The productivity method also referred to as the net factor income or derived value method, is used to estimate the economic value of ecosystem products or services that contribute to the production of commercially marketed goods. It is applied in cases where the products or services of an ecosystem are used, along with other inputs, to produce a marketed good. For example, water quality affects the productivity of irrigated agricultural crops, or the costs of purifying municipal drinking water. Thus, the increased revenues from greater agricultural productivity, or the decreased costs of providing clean drinking water can measure the economic benefits of improved water quality.

The productivity method was selected because this is a straightforward case where environmental quality directly affects the cost of producing a marketed good—municipal drinking water. This example is one of the simplest cases, where cleaner water is a direct substitute for other production inputs, such as water purification chemicals and filtration. Thus, the benefits of improved water quality can be easily related to reduced water purification costs.

Case Study Example of the Productivity Method – River Godavari Catchment and Pharola Water Treatment Plant.

Godavari Basin

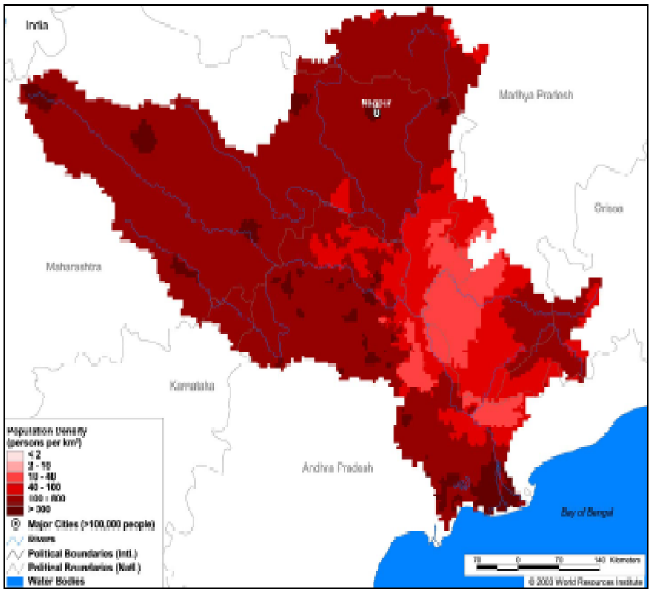
The second largest river in India, Godavari is often referred to as the Vriddh (Old) Ganga or the Dakshin (South) Ganga. The name may be apt in more ways than one, as the river follows the course of Ganga's tragedy: Pollution in this peninsular river is fast reaching unsafe levels. The Godavari originates near Triambak in the Nasik district of Maharashtra, and flows through the states of Madhya Pradesh, Karnataka, Orissa and Andhra Pradesh. Although its point of origin is just 80 kms away from the Arabian Sea, it journeys 1,465 kms to fall into the Bay of Bengal. Some of its tributaries include Parvara, the Purna, the Manjra, the Penganga, the Wardha, the Wainganga, the Indravati ,the Bindusara and Sarbari. Some important urban centers on its banks include Nasik, Aurangabad, Nagpur, Nizamabad, Rajahmundry, and Balaghat.

Godavari River is originating in the western part of India, and is subjected to multiple uses such as community water supply, irrigation, and industrial water supply. Godavari Basin extends over an area of 312,812 km^2,(see figure 3) which is nearly 9.5% of the total geographical area of the country. The basin lies in the states of Maharashtra (152,140 km^2), Andhra Pradesh (73,201 km^2), Madhya Pradesh (65,255 km^2), Orissa (17,752 km^2) and Karnataka (4,405 km^2). The Godavari basin consists of large undulating plains divided by low flat-topped hill ranges. The important soil types found in the basins are black soils, red soils, lateritic soils, alluvium, mixed soils and saline and alkaline soils. An average annual surface water potential of 110.5 km^3 has been assessed in this basin. Out of this, 76.3 km^3 is utilisable water. Culturable area in the basin is about 18.9 Million ha, which is 9.7% of the total culturable area of the country.

Increase in human population and urbanization in recent years resulted in gradual deterioration of water quality in the Godavari river. It was shown that water quality deterioration was associated with increases in industrial premises, domestic sewage discharges as well as non-point-source pollution including agricultural chemicals and eroded soils (CPCB, 1995).

Study Area

The river Godavari rises in the Nashik district of Maharashtra about 85 km from the shore of Arabian sea, at an elevation of 1100 m, after flowing for about 1500 km in a general south-easterly direction, through Maharashtra and Andhra Pradesh, Godavari falls into the Bay of Bengal above Rajamundry (see figure 4 a). The Godavari has a drainage area 313000 sq.km out of which 152140 sq.km lies in Maharashtra State.



Basin Area (sq. km): 319,810
Average Population Density (people per sq. km): 202
Number of Large Cities (>100,000 people): 1
Water Supply per Person (1995)(m3/year): 1,602
Degree of River Fragmentation: -
Number of Dams (>15m high) in Basin: 17
Number of Dams (>150m high) in Basin: 0
Number of Dams (>60m high) under Construction: 0
Number of Dams (>15m high) on Main Stem of River: 5
Number of Dams (>150m high) on Main Stem of River: 0

(Source: Water Resources eAtlas, Watersheds of Asia and Oceania AS07 Godavari)

Figure 3. Watershed of Godavari basin

The western edge of the catchment lies in the Sahyadri ranges of Western Ghats, which receives an annual rainfall of 1000 mm. The interior of the catchment is a plateau sloping towards the east. The northern boundary of the basin comprises a series of table lands varying from 600 m to 1200 m in elevation. The Southern boundary is the ridge, which divides Godavari basin with Krishna. The area selected as a case study is from its origin, Trymbakeshwar to Kopargaon (back water reach of Nath Sagar reservoir) as shown in figure 4 b. The river pollution problems potentially exist for this area, since there is currently large flow of untreated domestic and industrial wastes are being discharged into the river beyond its self-purifying capacity.

Pollution

India's fourteen major, 55 minor and several hundred small rivers receive millions of litres of sewage, industrial and agricultural wastes. Most of these rivers have been degraded to sewage flowing drains. There are serious water quality problems in the towns and villages using these rivers as a source of their water. Like most other rivers, domestic pollution is the biggest polluter of the river Godavari, accounting for 82 per cent of total pollution, whereas industrial pollution accounts for about 18 per cent. Over half of the river basin (18.6 million ha), is categorized as cultivable land. Most of the river's water is drawn for irrigation purposes. Application of fertilizers is very high at 49.34 kg/hectares, almost double the country's average. Pesticides are also applied at the high rates of 146.47-kgs/sq. km of which 79 per cent are organochlorines.

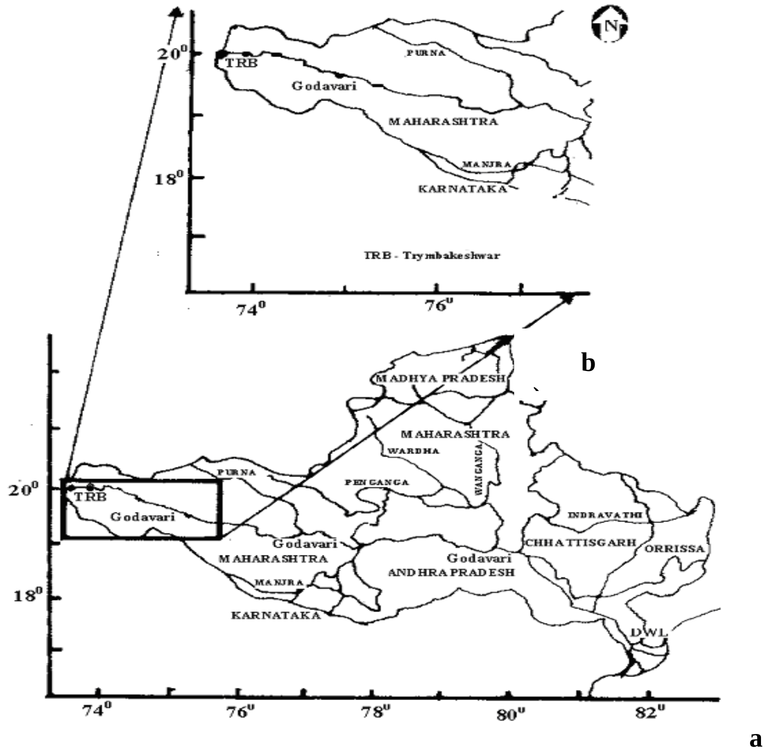


Figure 4. a) Location and extent of Godavari River Catchment Area; b) Study area

Water is purified in large part by the routine actions of living organisms. Energy from sunlight drives the process of photosynthesis in aquatic plants, which produces oxygen to break down some of the organic material such as plant and animal waste. This decomposition produces the carbon dioxide, nutrients and other substances needed by plants and animals living in the water. The purification cycle continues when these plants and animals die and the bacteria decompose them, providing new generations of organisms with nourishment. Unfortunately, there are many toxic substances, which are affected only slowly, or not at all by this and other processes. These are called persistent and are of great environmental concern.

The Godavari rises near Trimbak in Nasik, Maharashtra. The river is 1,465 km along and joins the Bay of Bengal in Andhra Pradesh. It has a catchment area of 31 mha. The mighty river contributes about 3000 tmc of water annually at 75% dependability. The maximum flood so far observed is about 35 lakh cusecs at Dowalaiswaram anicut. Flowing in our state it is fed by tributaries like Penganga, Pranahita, Sabari, Indravati, Manjeera and Manair. On account of the high concentration of population, industries, towns and cities in the basin, large quantities of domestic and industrial wastes are discharged into the river. Wastewater from agriculture, animal care, domestic and industrial uses reach the river by leaching, drainage and surface wash-off during the monsoon. The application of fertilisers in the Godavari basin is 49.34 kg/ha, which is more than twice the national average. The total BOD load is 998 tonnes, whereas the total consumption of pesticides in the basins in Andhra Pradesh, Madhya Pradesh and Maharashtra is 21,586 tonnes. Industry produces a total of 808 million cubic meters of waste annually. About 90,600 kg, that is, around 17.94% of the BOD load is from industrial sources. In addition to BOD load, industry releases various toxic pollutants in the rivers. The organic pollution load contributed daily by the urban sector alone comes to 414 tonnes/day.

The study reported that moderate level of organic pollution was detected in the lower reach of the river at Nashik and Eklara. The organic pollutants, mainly from untreated sewage, animal wastes, agricultural chemicals and industrial effluents, not only result with pollution in the watercourse but also pose risks of eutrophication in the river (see figure 5) and at the reservoirs. Although these organic nutrients and persistent organic pollutants can now be effectively removed during water treatment processes, their long-term damages to the aquatic ecosystems are worthy of concerns.

Figure 5. Status of River Godavari at Eklara near Nashik(Author).

Water quality is measured in terms of parameters like Biochemical Oxygen Demand (BOD), Dissolved Oxygen Demand (DO) and Total Coliform Count. BOD is a measure of water pollution based on the organic material it contains. The organic material provides food for aerobic bacteria, which require oxygen to be able to bring about the bio-degradation of such pollutants. The greater the volume of organic material and the greater the number of bacteria, the greater will be the demand for oxygen. Thus, the BOD value gives an indication of organic pollution levels in the water. If BOD exceeds the available dissolved oxygen in the water, oxygen depletion occurs, and aquatic organisms suffer. Fish kills are not uncommon under such circumstances

To identify the substances present in a stream or lake, scientists collect samples of the water, of living organisms, and of suspended and bottom sediments. Technicians then analyze these samples in a laboratory with specialized instruments and procedures. Certain measurements such as temperature, dissolved oxygen, turbidity and conductivity can be taken in the field with portable equipment. Today's analytical laboratory instruments - with such high-tech names as "plasma emission spectrometer" (for analysing metals) and "gas chromatograph-mass spectrometer" (for analysing pesticides, PCBs dioxins, and other organic compounds) - bear little resemblance to the test-tube and gas burner laboratories of the 1950s. Nowadays the analysis of water and sediment samples detects more substances than a decade ago, partly because there is more substances present in water, but also because of improved analytical instruments and consequently lower detection limits. State-of-the-art analytical instruments can detect down to one part per trillion of some substances - comparable to tracing one thousandth of a teaspoon of salt dissolved in an Olympic-size swimming pool.

Water Supply Scheme of Aurangabad

Aurangabad is capital town of backward region under tourist city historically the city has been part of a politically important region. The Shaliwahans, who had their capital at Pratishthan (Paithan) ruled for almost 400 years. This is a historical record, which no other dynasty in the world has surpassed. It was due to this & others who came later, that the region has now the world famous Ellora & Ajanta monuments. But the city proper is the brainchild of Milk Amber who established it in 1610, on the site of a village called Khadki.

Malik Amber developed a system of pipelines for water supply to the entire city. Called Nahre-Ambari, the system works well even today, i.e. after 300 years. By this token alone, it is a feat of engineering. It is now being exploited for agriculture, wherever it passes through a field, there is no caretaker. The INTACH Centre of Aurangabad has been after the authorities to declare it as a national monument, but so far nobody has taken any notice. Presumably everybody in authority thinks that we have enough of monuments, and we don’t need any more.

Same is the fate of other monuments in the city. The city is literally flooded with monuments from all periods, right from Satwahanas to theMoghuls & Nizam, Most of these are in the thickly populated areas of the city, and the inhabitants have enough to worry about the present. They have been solving their present day problem of collecting building materials by plundering the historical monuments. Aurangabad was a city fort with a wall all around. The large fort wall has mostly vanished, only the Gates remain. There were about 52 Gates, marking entry to the fort, now about 21 are standing, the rest have either fallen prey to plunderers or have collapsed on their own. Except INTACH, nobody so far has taken any notice.

Originally, Aurangabad had Municipal Council, comprising of an area of 54.40 Sq.Kms. In 1982, it was converted in a Municipal Corporation, encompassing a total area of 138.53 Sq.Kms. However, the growth of the city is highest in its original boundaries, and most of the outer area is still green.

CIDCO came to Aurangabad in the '70s, and has helped enormously. It catered for the growth in the city, which started with the growth in the industries, and saved Aurangabad from the fate of cities like Pune. In most of the cities where the growth in population due to industrial growth was not accounted for, the cities have been flooded with slums. This dose not means we have no slums, but that is another story.

Climate

The temperature fluctuates from December to May. The mean of Daily max is 103.5 F (38^0 C) in the month of May and mean of daily minimum is 50.8F (10.5^0 C) in the month of December. The extreme highest recorded temp is 114 F (45.5^0 C) the temp is mainly influenced by the Vapour bearing currents known as summer & winter monsoon. It has been observed that March, April, May is hot months while Dec, Jan & Feb are cold months.

The wind blows from east to west for maximum period in the winter season but it blows from west to east in other seasons. The wind blows with highest speed of about 11 miles per Hour in May; June; July and August. The best orientation for the buildings is east to west. The climate is generally healthy but during the rainy season and winter seasons, malaria prevails. The rainy season is from June to September, winter is between Oct to Jan. rest is summer.

Utilities and Services

Water supply is available to Aurangabad city through Jayakwadi Dam; Harsool tank there are reservoirs at different places of the city for the distribution of water. The drinking water demand for Aurangabad city is 150 MLD; treatment and transit losses culminate to 7.5 MLD. The drinking water demand in 2021 would be around 600 MLD including the losses about 12.71 TMC per year including MIDC water demand of 17.7 TMC per year.

Pharola Treatment Plant

Pharola water treatment scheme was started in 1976, which was designed for a capacity of 28 ML. Source of water being taken from NathSagar river intake wells placed at the Jaikwadi dam, which is 27 KM from the treatment unit. The source water is alkaline in nature and less turbid .As the years passed the population of Aurangabad City rapidly started to increase due to industrialization of the city. To overcome this increase in demand of water in 1985 boosters were installed and the capacity was increased to 50ML.

This merely fulfilled the required water demand, so the govt. came up with another scheme and proposed to start a new scheme that was completed in 1992.The new scheme had a capacity of 100ML, which could be extended by boosting to 200ML capacity. At present the treatment unit supplies Aurangabad with 140MLD.

Treatment Process At Treatment Plant

The treatment unit gets it water from Jaikwadi dam having a water head of 70m, where the intake wells are provided which supplies water through pressure conduits (rising mains) to the treatment unit 27km from the intake wells the dia. of the pressure conduits is 700mm old line and 1200mm new line. The water reaches the first unit of the treatment unit i.e. the inlet chamber for aeration which is done by allowing the water to pass through a approach channel with a flume .The water at this stage is pre chlorinated and coagulated with chlorine dosage of 2mg/l and alum dosage of 5mg/l. From here the water comes to the flash mixer which mixes the coagulant with the water in a detention time of 30 sec, then forwards it to the clariflocculators where the coagulants react with the colloidal impurities and form flocs which settle here within the detention period of 3.5hrs. Water from here moves on to the filter beds where it under goes filtration at the rate of 5000 to 6000 lit/sq.m/hr. Water is then chlorinated with a dosage of 5mg/l to attain residual chlorine of 0.2 to 0.5 mg/l then send to the ground storage from where it is pumped to the master balance reservoir and the ground storage reservoir at Nakstrawadi which is at an elevation 140m above treatment plant. From Nakstrawadi the water is supplied to Aurangabad through gravity main of dia. 1400mm to various storage units in the city. Some units situated in the city at various locations are as follows: Elevated storage reservoirs are located at the following place in the city Mitmita, Padegaon, University, MGM, Spinning mill, Polytechnic, Jinsi, Saint Francis, Marimate (GSR), Kranti chowk (master chamber). Water from these units are supplied to the consumers.

Monitoring of water samples were carried out during Jan 2 to April 7, 2001. Samples were collected to assess the time dependent variations in the quality of water and to examine the over all performance of the treatment plant. The sampling locations selected through out the treatment sequence are shown in the figure 6. It may be noted from the figure 6 that the sampling points are so chosen to enable study of individual unit operation. The data for one year was collected from the plants logbook also. Samples were collected at regular intervals on weekly basis the samples were collected every Saturday and analysed Very day as per the standard methods recommended by the American Public Health Association (1998) (Figure 7).

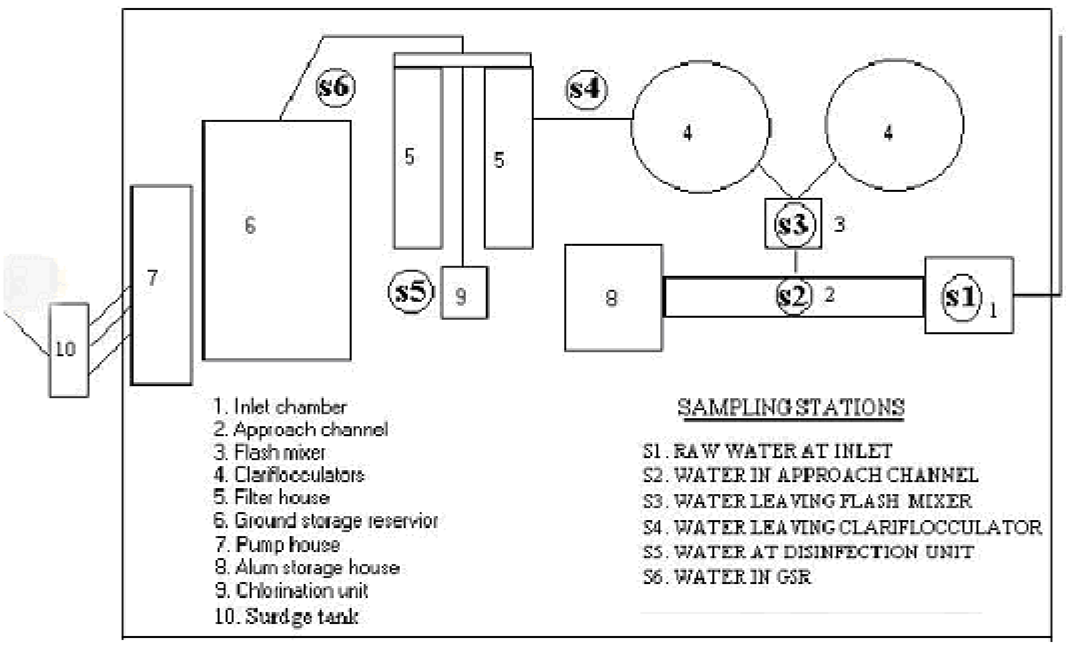


Figure 6 Location of Sampling Stations at Pharola treatment Plant

a) b) c)

Figure 7.a) Samples collected at various locations; b) & c) Analysis of Samples

(Source: Benny Arun and Abhishek Ahuja)

Results and Discussion

Results

Figure 8 clearly indicates that the turbidity is directly proportional to the enhanced use of chemicals, like ALUM and Chlorine. It is revealed that during rainy season months the cost of chemicals is approximately double the normal cost of operation. Adopting soil conservation and watershed development techniques at catchments area can reduce this. The vegetative cover of the catchment not only prevents the soil erosion but also recharges the ground water.

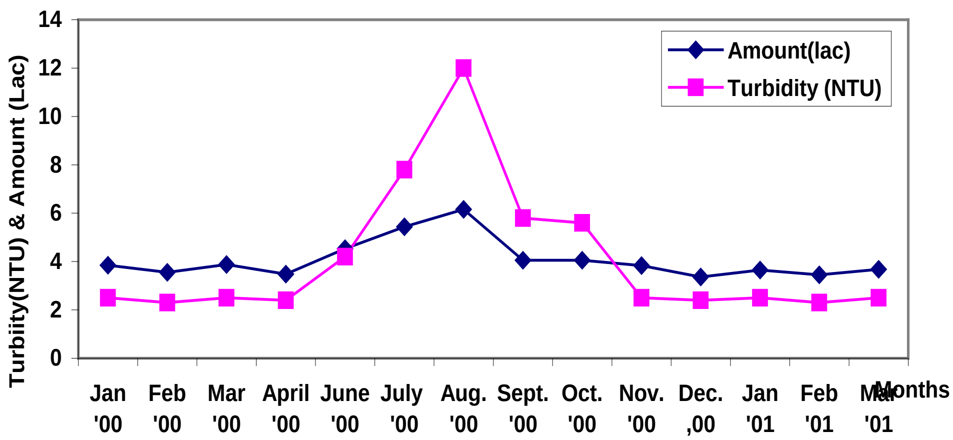


Figure 8. Cost of Chemicals incurred and Turbidity of raw water

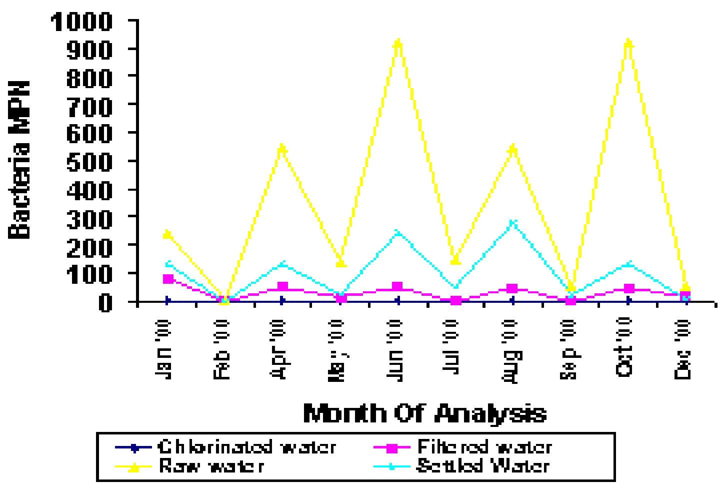


Figure 9. Chart showing the bacterial count

Discussions

The study reported that moderate level of organic pollution was detected in the lower reach of the river. The organic pollutants, mainly from untreated sewage, animal wastes, agricultural chemicals and industrial effluents, not only result with pollution in the watercourse but also pose risks of eutrophication in the river and at the reservoirs. However these organic nutrients, persistent organic pollutants can now be effectively removed during water treatment processes (at an additional cost) their long-term damages to the aquatic ecosystems are worthy of concerns. The excess use of the purification chemicals (Alum & Chlorine) in the treatment plants to bring down the water quality parameter like Turbidity and bacterial count arise manifold problems. Excess use of Chlorine forms trihalomethenes, which are carcinogenic. Similarly, excess use of Alum makes water more alkaline and hard.

Conclusions

The study results reveal that adopting the soil and water conservation techniques in catchment area; reduce the cost of purification chemicals required at treatment plant. It not only helps in preserving the ecosystem but also protect the human beings from the side effects of overdosage purification chemicals. The cost of purifying water where runoff is not controlled is always on higher side.

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