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Fishes as Environmental Indicators of Riverine Ecosystem.

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Abstract: The ecological condition of river is represented by the condition of their biotic communities — the living components of aquatic ecosystems that integrate many forms of human disturbances and modification of river stream and the measurements of this subject was the topic of particular interest. Stressors or the pressures that human being exert on aquatic systems through their use of the surrounding environment are commonly the chemical, physical and biological components of the ecosystem. These have the potential to degrade biotic integrity. Some common chemical stressors are toxic compounds, excess nutrients etc. Most of the physical stressors are created when we modify the physical habitat of a river network-excess sedimentation, bank erosion etc. All these can degrade biotic integrity. Water quality plays vital role in riverine ecosystem health regulation. Environmental indicators have been defined as "physical, chemical, biological or socio-economic measures that best represent the key elements of a complex ecosystem or environmental issue. An indicator is embedded in a well developed interpretative framework and has meaning beyond the measure it represents. Using indicators, it is possible to evaluate the fundamental condition of the environment without having to capture the full complexity of the system. Indicators are based on the best scientific understanding currently available so that changes in these simple measures can be related to more complex environmental trends.
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Key Words:- Ecosystems, Habitat, Indicators

Introduction

When we speak of assessing the ecological condition of river Kosi, district Khagaria, Bihar we focused on evaluating two critical components of aquatic ecosystems i.e. the condition of biota and the relative importance of human-caused stressors. Stressors or the pressures that human being exert on aquatic systems through their use of the surrounding environment are commonly the chemical, physical and biological components of the ecosystem. These have the potential to degrade biotic integrity. Some common chemical stressors are toxic compounds, excess nutrients etc. Most of the physical stressors are created when we modify the physical habitat of a river network-excess sedimentation, bank erosion etc. All these can degrade biotic integrity. Water quality plays vital role in riverine ecosystem health regulation.

Many workers have done extensive work on the ecological assessment of aquatic systems with eco-health as their priority. Some of them are Frey (1977), Newson (1977), Karr and Dudley (1981), Karr (1981), Wharfe *et al* (1984), Schaeffer *et al* (1985), Hellawell (1986), Elliot *et al* (1988), Faush *et al* (1990), Costa and Elliot (1991), Costa *et al* (1992), Boodoosing (1992), Ober droff & Huges (1992), Dennison *et al* (1993), Roux *et al* (1993), Hamerlynck and Hostens (1994), Little and Smith (1994), Elliot and Dewailly (1995), Barbour *et al* (1995), Whitfield (1996), Paller *et al* (1996), Elliot (1996), Postel (1996), Deegan *et al* (1997), Blaber (1997), Soto *et al* (1998), Phillip (1998), Oslen *et al* (1998), Pringle and Scantena (1999), Leamon *et al* (2000), Blaber *et al* (2000), Baird *et al* (2000), Bain *et al* (2000), Wright (2000), U.S. Environmental Protection Agency (2000), Kurtz *et al* (2001), Elliot and Hemingulay (Eds.) (2002), Elliot (2002), Peck *et al* (2005), Peek *et al* (2005), Stoddard *et al* (2005), Gupta and Pankaj (2006), Singh and Singh (2007), etc.

There is a growing interest in the use of biological communities to assess the status of water resources (Deegan *et al*., 1997; Bain *et al.,* 2000; Simon, 2000). While many investigations aimed at detecting environmental and ecological changes within estuaries have focused primarily on water quality (eg. Nitrate level or BOD) and the associated biota (eg. Aquatic plants, invertebrate), there are relatively few studies based solely on fishes (Costa *et al*., 1992; Dennison *et al*., 1993). In addition, monitoring programmes focusing on ichthyofauna

(Paller *et al*., 1996) seldom address changes over more than one level of biological organization.

Materials And Methods

It is possible to generate a generic framework for the use of fishes as river environmental indicators with regard to definition, classification, monitoring, assessment, reporting and management and within this to denote the parts of the framework dependent on the development and use of indicators for environmental health and indicators of response to change in health.

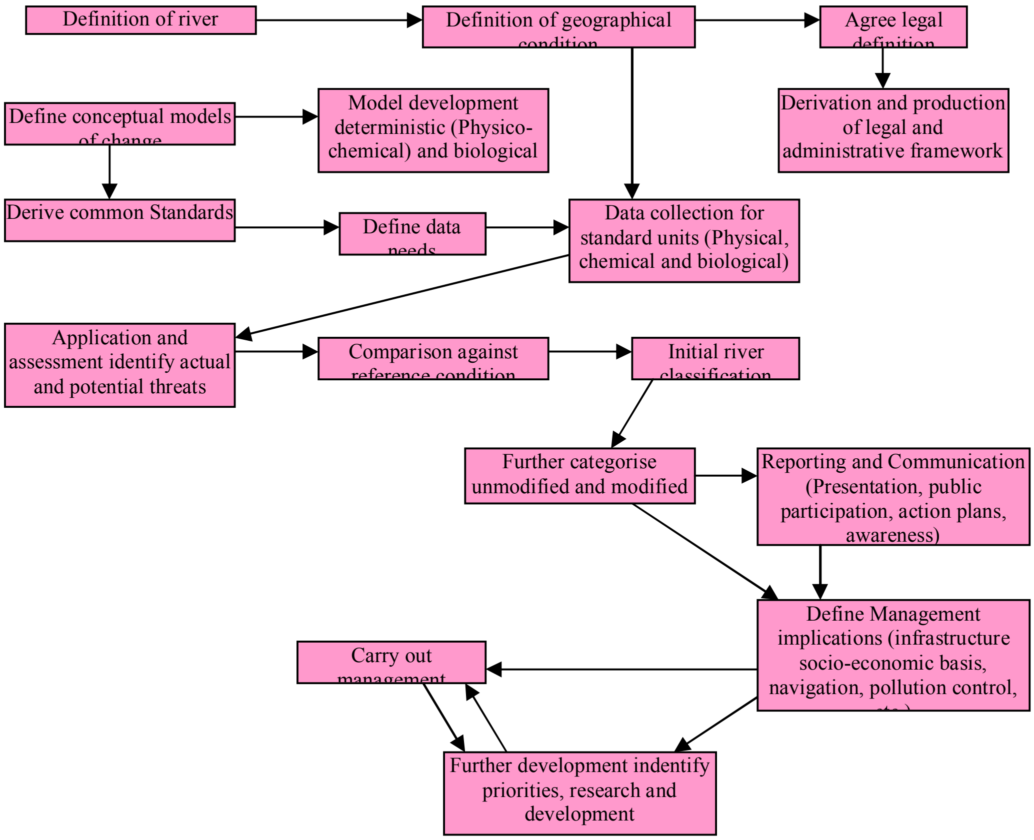

Fig. showing generic framework of fish indicator use

Anthropogenic impacts can target both the biotic (e.g. fish abundanie and biomass) and abiotic (e.g. river flow and turbidity) components of the ecosystems. Surface water sample were collected between 7:00 to 10:00 hrs. monthly from July 2005 to June 2007. The Indian standard methods used for sampling ISI (1973). Temperature of air and water measured with the help of centigrade thermometer, pH by pH paper and with the help of electronic pH meter and other parameters were analysed by using standard methods APHA (1986) and Trivedy and Goel (1986), Koarkar (1992),

Dissolved oxygen (DO_2), free carbon dioxide (FCO_2) were analysed in the laboratory. Following methods were adopted for the detailed analysis.

Physical Parameters

(i) Temperature

Air and water temperature were recorded with the help of a centigrade mercury thermometer graduated upto 110°C. Average of three readings were taken as the standard temperature.

(ii) Turbidity

Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in straight lines through the samples.

The turbidity of the water samples was measured by the nephaloturbidity meter (Type - 131). The value was expressed in terms of N.T.U. (Nephalo Turbidity Unit).

The method is based on comparison of the intensity of light scattered by a sample and a standard reference under same conditions. For this 5ml of hydrazine sulphate solution (1%) mixed with 5ml of Hexamethylene tetramine solution (10%) and diluted to 1000ml. 10ml of this solution was diluted in 400ml forming turbidity standard.

(iii) Conductivity

It is the numerical expression of the ability of water sample to carry an electric current. It was measured by Conductivity Bridge 305. The value was expressed in µv (micro mhos).

(iv) pH

Hydrogen in concentration of the river Kosi water was alkaline throughout investigation period except few months of the monsoon. It was the range of 6.8 to 8.4 pH was higher in winter (7.6 to 8.3 and 7.3 to 8.4). Followed by summer (7.5 to 8.1 and 7.5 to 7.9) and Monsoon (6.8 to 7.5 an 6.9 to 7.6) respectively of 2005-06 and 2006-07.

Chemical Properties

(i) DO_2

Dissolved oxygen was estimated by winkler's method also known as Alsterberg azide modification described by Welch (1948).

Magnous sulphate, concentrated sulpuric acid and N/40 Sodium thiosulphate solution were used as reagents and starch solution used as indicator. NaN_3 (Sodium azide) was used as preservatives in the alkaline iodide solution value was expressed in $mg.1^{-1}$

(ii) FCO_2 (Free Carbon dioxide)

FCO_2 was analyzed as described by Welch (1948).

100 ml. sample water was titrated against N/44 NaOH solution. Phenolphthalein was used as indicator value was expressed in $mg.1^{-1}$

Observations

Some of these indicators will then be used to explain to the public and policy-makers the nature of changes as a result of human activities, others may be used as diagnostic to quantify the consequences of any change. For example, a change in the fish community may be the result of anthropogenic activity such as a polluting discharge, but also such a change may be quantified in order to determine whether man is having a significant effect on the system or not.

Many groups of organisms have been proposed and used as indicators of environmental and ecological change (Karr *et al*., 1986). Although no single group is favoured by all biologist, it appears that fishes, macroinvertebrates, birds and plants have received the most attention (Schaeffer *et al*., 1985; Morrison, 1986; Fausch *et al*., 1990; Dennison *et al*., 1993). Fishes have been successfully used as indicators of environmental quality changes in a wide variety of aquatic habitats (Whitfield, 1996; Soto-Galera *et al*., 1998) and have numerous advantages as indicator organisms for environmental monitoring programmes, including (1) they are typically present in all aquatic systems, with the exception of highly polluted waters; (2) there is extensive life-history and environmental response information available for most species; (3) in comparison to many invertebrates, fishes are relatively easy to identify and most samples can be processed in the field, with the fishes being returned to the water (4) fish communities usually include a range of species that represent a variety of trophic levels and include foods of both aquatic and terrestrial origin; (5) fishes are comparatively long lived and therefore provide a long-term record of environmental stress; (6) they contain many life forms and functional guilds and thus are likely to cover all components of aquatic ecosystems affected by anthropogenic disturbance; (7) they are both sedentary and mobile and thus will reflect stressors within one area as well as providing groups to give a broader assessment of effects; (8) acute toxicity and stress effect can be evaluated in the laboratory using selected species, some of which may be missing from the study system; (9) they have a high public awareness value such that the general public are more likely to relate to information about the condition of the fish community than data on invertebrates or aquatic plants; (10) societal costs of environmental degradation, including cost-benefit analysis, are more readily evaluated because of the economic, asthetic and conservation values attached to fishes. The use of fishes as indicators of biological integrity, however, does have difficulties and problems, including (a) the selective nature of sampling gear for a certain habitats and sizes and species of fishes; (b) the mobility of fishes on seasonal and diet time scales can lead to sampling bias; (c) fishes may be relatively tolerant to substances chemically harmful to other life forms; (d) fishes can swim away from an anthropogenic disturbances, thus avoiding localized exposure to pollutants or adverse environmental conditions; (e) river environments that have been physically altered by humans and natural causes may still contain diverse fish assemblages.

Many of the disadvantages described above are out-weighed by H widespread advantages. In addition it should be emphasized that a number of the negative aspects would also apply to other taxonomic groups (i.e. invertebrates) that may be used in biological monitoring of the aquatic environment.

Riverine forcing variables and Fish Response

The major physical drivers in terms of the biological or Ichthyological functioning of river can be found under geographical and hydrographical categories. These variables create the conditions available to the fishes but, depending on their environmental and physiological tolerances this basic community becomes influenced by other biological variables such as predator prey interactions and inter and intra-specific competition (Elliott & Hemingway 2002).

Both physical and biological variables contributes to niche production (or elimination) within river but it is primarily the environmental variables that are driving the response of the biota, including the ichthyofauna (Green, 1968; Blaber, 1997). Therefore, the measurement of any ecological response by the fish community, or individual species within that community, must take cognizance of the key role played by the physico-chemical environment in influencing the structure and functioning of that river.

Anthropogenic impacts can target both the biotic (e.g. fish abundanie and biomass) and abiotic (e.g. river flow and turbidity) components of the ecosystems.

The key responding variable that is directly and frequently influenced by human is fish species abundance and biomass.

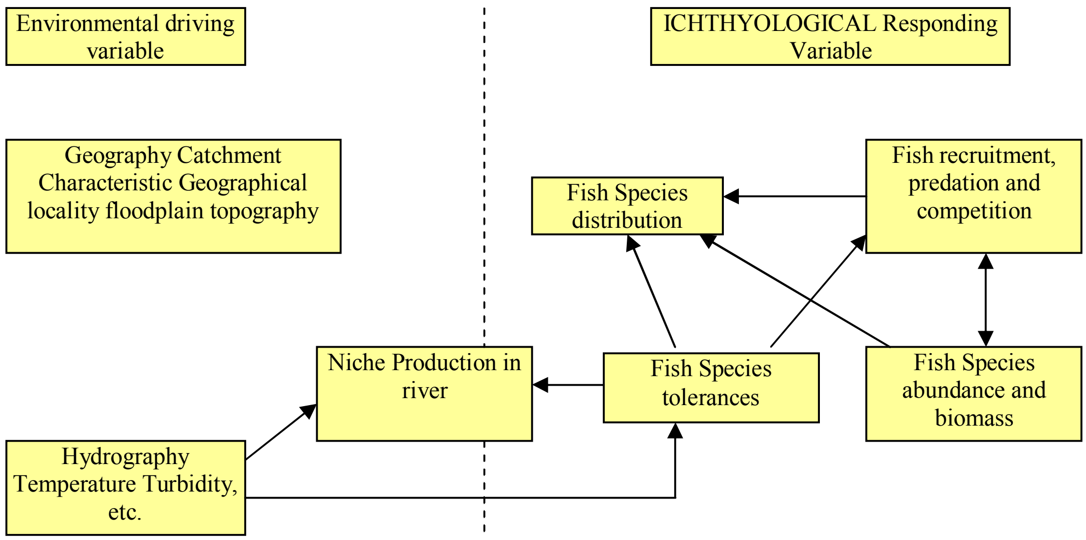

Fig. Shows Interactions between selected environmental and Ichthyological variables in river (*variable often influenced by anthropogenic activities) and the prime effect of fishing in river Kosi at Sonbarshaghat can be seen to have a large no. of ecosystem effects (Blaber *et al*., 2000; Elliott & Hemingway, 2002).

There are numerous examples of the effects of over fishing on riverine fish stocks, including declines in the populations of certain over exploited fish species being reflected in declining riverine abundance. For example (Elliott *et al*., 1990) have shown that declining Juvenile cod Gadus morhua L. populations in the Fourth Estuary during early 1980s reflected more widespread changes (due to overfishing) in the stocks of this species.

Fishes as Tool of Ecological Change

The use of fishes as indicators of environmental or ecological changes to aquatic systems is based on the fact that fish species and fish communities are sensitive indicators of change within these system (Karr, 1981; Shamsudin, 1988). Biological monitoring is preferred to chemical monitoring because the latter often misses many of the anthropogenic induced perturbations of aquatic ecosystems, e.g. habitat degradation. Hocutt (1981) suggested that structurally and functionally divers fish communities provide evidence of water quality in that they incorporate all the local environmental perturbations into the stability of the communities. He concluded that fish communities present a viable option for assessing human related impacts on freshwater ecosystems.

Following factors are used in analysis of Ecosystem health—

1. Shifting Course

The river Kosi is well known for extensive branching into many interlacing channels in its course. It does not remain static in a fixed channel for a long time. Since ancient times, it has been oscillating over a vast tract of North Bihar. This wild movement of the river has been taking sudden jumps from one channel to another. In this process, it deserts the previous ones which still hold on some water Chibber (1949), leading to the formation of swamps and wetlands. The only comparable river in this respect is the "Hwang-Ho of China" (Ahmad, 1947).

Causes of Shifting Tendency:

The oscillating character is associated only with the Kosi and no other river of the region. The causes of oscillation have puzzled hydrobiolgist, geographers and geologist. Furthermore, the westward shifting tendency of the Kosi shows in figure as the natural slope (North-west to South-east) and configuration of the region is more amazing. Several explanations have been given by different authorities from time to time. However, the most common and widely accepted explanation given by Das (1968) and Singh (1986) deserves special attention. According to these authors, siltation, rapid water discharge, and bed slopes of the

Kosi flood plain, are responsible for ever shifting nature of the river. It shows in table 1.

Table - 1 Approximate rate of movement during 1736-1950

Years	Period of Movement (Years)	Distance (Miles)	Moved in Km (s)	% Movement	Average movement (%) per year
1736-1770	34	6.7	10.78	10	0.29
1770-1823	53	5.8	9.34	8	0.15
1823-1856	33	3.8	6.12	5	0.15
1856-1883	27	8.0	12.87	11	0.40
1883-1907	24	11.5	18.51	16	0.67
1907-1922	15	6.8	10.94	10	0.66
1922-1933	11	18.0	21.97	25	2.27
1933-1950	17	11.0	17.70	15	0.88

Source: Kosi Project Dept. Govt. of Bihar, Patna Secretariat, Patna, 2001.

2. Sedimentation load of the Kosi Siltation

The river represents abnormally high rate of still yield per unit catchment area, which is higher than that of any other river in the world including the yellow river of China (Mookerjee, 1971). The devastating flood waters of the Kosi bring enormous quantities of silt and sand as load which is adversely affecting the vast area of fertile land, estimated to be 5,20,000 to 8,00,000 ha in Bihar. (United Nations, 1951).

The bed slopes of the Kosi ranges from 5 to 1 foot per mile upto its middle reaches and less than one foot per mile in its tail end near its confluence with the Ganga at Kursella (Das, 1967). On account of this progressive flattening of the slope, the river is unable to transport all the sediment loads received at Chatra down to the Ganga. Hence, the sediment load gets deposited in the river bed at various places. River Kosi loaded every year 950 lakh Cus (The Hindu-08). As regards the total runoff the sediment load, maximum amount of sediment yield (94.72%) comes down the river during the monsoon season alone, for the remaining part of the year it is very nominal (i.e. 5.17%) (Singh, 1998). Also reported by (Munshi *et al*., 1991) in monsoon seasons (2.452g/l) and September (2.500 g/l). We found the following data in respect to month in the year of 2005-06 and 2006-07.

TABLE - 2 Silt Discharge (G/L)

Months	2005-06	2006-07
June	1.294	1.320
July	2.352	1.749
August	2.090	1.470
September	1.591	2.400
October	0.503	1.370
November	0.168	0.728
December	0.098	0.102
January	0.075	0.060
February	0.068	0.077
March	0.056	0.118
April	0.0376	0.133
May	0.233	—

Source: Kosi Project Dept. Govt. of Bihar, Patna Secretariat, Patna, 2001.

Sedimentation-load-concentration indicate that the Kosi, in spite of being one of the largest rivers of the Himalayas, exhibits really the distinctive features of an extremely flushy hill torrent (Jha, 1979).

Temperature

In the present investigation period temperature ranges from 20.2°C to 35.5°C during 200-06 and 21.2°C to 33.5°C during the period of 2006-07. The atmosphere temperature is more close during the winter season to water temperature.

Turbidity

The value of turbidity was found in between 80 to 500 N.T.U. in the year of 2005-06 and 70 to 450 during the 2006-07. Turbidity of any water sample is the reduction of transparency due to the presence of particulate matter such as lay or silt, finely divided organic matter, plankton and other microscopic organisms. Akuskar and Gaikwad (2006) observed higher turbidity during monsoon and minimum during winter. In the my investigation the higher turbidity was evident in the summer season maybe due to low depth and lower during winter season. Detail data of turbidity explain in Chapter II.

Conductivity

It measures the capacity of a solution to conduct electric current through it and depends on the concentration of ions load of nutrients. Salts are present in ionic form in water, due to ionic form of salt water capable to conducting current. Many worker work on the aquatic conductivity capacity of different rivers Sahu *et al* (1996), Sharma (2003), Prasad (2005), Zaimoglu *et al* (2006), Marchese *et al* (2008), etc. During the my investigation lowest value of conductivity was found in rainy season and highest in summer and winter seasons during 2005-06 and 2006-07.

Reckless Fishing

Fishing is an important parameters for any aquatic ecosystem and Ichthyofauna. It has been observed that the fishing at the Sonbarshaghat is recklessly done by the peoples. During the breeding season fishing was done and there is no any restriction followed by people. People use the different types of gear for the capturing of fish detailed information given in Chapter 3. A most dangerous fishing gear i.e. Mosquito nets are also used for capturing of fish.

Fish Diversity

About 71 species belonging to 23 different families were recorded in the present study. The most abundant fish species in the study belonged to family Cyprinidae and less abundant family were Chacidae and Tetrodontidae.

Catch

The catch statistics of cat fish *Rita rita* (Ham.) during one year catch study (2005-2006) show that the maximum load was in the month of August i.e. 4.60% of the total fish whereas the minimum recorded during the month of December i.e. 0.80% of the total fish catch. This percentage of catch relates to the average landing in the different months of the study period. It has been realized that the earlier abundant fish species have gone to very low due to habitat destruction and different allied reasons. The local people opined that lesser volume of water and little recruitment of fresh fishes have resulted in drastic reduction in the total fish catch.

Chemical Parameters

DO_2

Dissolved oxygen is one of the important parameters to assess the water quality. Its presence is essential to maintain variety of forms of life in the water. Inorganic reducing agents such as H_2S, ammonia, nitrate, ferrous ion and certain oxidizable substances also tend to decrease dissolved oxygen in water Saha *et al* (2000), Mishra and Tripathi (2007) etc. work and effect of DO_2 in aquatic ecosystem. We found that the value of DO_2 during summer is low i.e. 6.5 and during the winter season it is high i.e. 11.44 ranges during both year investigation respectively.

FCO_2

The value of FCO_2 was recorded from nil during winter to 10.5 mgl^{-1} in monsoon.

Nitrate Nitrogen

Generally, nitrates are formed in water, due to bacterial action oxidation of ammonia and are readily oxidized to nitrates. The nitrites in water are indicative of organic pollution. Biological decomposition of all nitrogenous organic matter such as sewage and animal waste contribute nitrite values in water we found the nitrate nitrogen between the range.25 to 1.88 mgl^{-1} minimum during the summer and higher during the monsoon season. It is also a source of fertilizers used by the farmer at that area.

Phosphate

Phosphates are obtained from the rocks converting then into its soluble forms and may also occur, in agricultural runoff, municipal sewage, synthetic detergents, industrial wastes. During the course of investigation we found that the value of 0.14 mgl^{-1} and.80 mgl^{-1} during winter and monsoon respectively. About all chemical parameters we describe in this chapter and fish gears given detail description in previous chapter.

Result And Discussion

The eco-health of Kosi explains the aquatic eco-factors inclusive of abiotic and biotic components as well as any allochthonous compound affecting the steady state or homeostasis.

The studies made in the earlier chapters clearly show that the abiotic factors are much away from the normal parameters. The fish diversity has also been found to be reduced substantially due to high siltation rate. The river frequently changes its course of movement and consequently has bearing upon the habitat of the fishes. Catch statistics of representative fish *Rita rita* is in alarming state. This fish is bottom dweller and preferably take shelter in the crevices or holes in the stone or between the shingles. Regular intense silting has filled up most of the cave and thereby the natural abode of *Rita rita* (Ham.) have been destroyed.

The irrational and reckless fishing has played a vital role in the deterioration of fish catch as well as diversities of fish species. The increased level of silicate in the water restricts the no. of bacillariphyceae, the diatoms reduced population of diatoms is also a major factor responsible for reduction in fish population. Continuous high pH was recorded in the present investigation that becomes a limiting factor for the proper growth and development of ichthyofaunal diversity. The siltation has caused reduction in river depth. This low depth profile of the river has been also one of the important factors for controlling the growth of bottom dweller fishes like *Rita rita* (Ham.)

The uncontrolled and unethical fishing of juveniles and brooad fishes have direct impact on the number of fish population. The fisherman use different nets like Kapda jal (net of mosquito) which enable them to fishout even the spawns, frys and fingerlings. The destruction in the ichthyofaunal diversity particularly the fish under studies i.e. *Rita rita* is indicative of environmental degradation. Sumsuddin (1995) has expressed that the fish species are sensitive indicator of change within the system. Diverse fish community affirmly provide evidence of good water quality which was uncommon during the present study. Hence the eco-health of river Kosi suggest that by estimating a number and diversity of fish species should be correlated with the ecological condition. Regular dredging is required for the maintenance of the river ecology and biotic population.

Conclusion

The uncontrolled and unethical fishing of juveniles and broad fishes have direct impact on the number of fish population. The fisherman use different nets like Kapda jal (net of mosquito) which enable them to fishout even the spawns, frys and fingerlings. The destruction in the ichthyofaunal diversity particularly the fish under studies i.e. *Rita rita* is indicative of environmental degradation. Sumsuddin (1995) has expressed that the fish species are sensitive indicator of change within the system. Diverse fish community affirmly provide evidence of good water quality which was uncommon during the present study. Hence the eco-health of river Kosi suggest that by estimating a number and diversity of fish species should be correlated with the ecological condition. Regular gredging is required for the maintenance of the river ecology and biotic population.

Physico-Chemical Properties Of River Kosi At Sonbharsaghat Distt.- Khagaria, Bihar

Parameters	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**
Atmospheric Temp. (°C)	33.5	32.5	33.0	28.0	26.2	20.2	21.0	23.0	30.0	32.0	33.0	34.5
Water Temp. (°C)	31.0	30.0	31.0	27.0	23.0	19.0	18.6	24.0	25.6	27.6	32.0	32.2
Turbidity	240	500	460	290	110	100	90	85	80	95	110	130
Conductivity	510	540	550	600	645	790	850	1005	990	780	720	590
pH	7.4	7.4	6.8	7.4	7.5	7.9	8.3	8.2	8.0	7.9	7.6	7.4
DO_2 (mg.1^{-1})	7.7	6.7	6.16	6.7	8.2	10.2	11.44	8.75	8.5	8.4	6.67	6.45
FCO_2 (mg.1^{-1})	8.1	10.2	4.01	2.1	1.41	-	-	-	-	-	-	4.02
PO_4—P (mg.1^{-1})	0.45	0.80	0.80	0.70	0.66	0.53	0.26	0.37	0.42	0.34	0.58	0.64

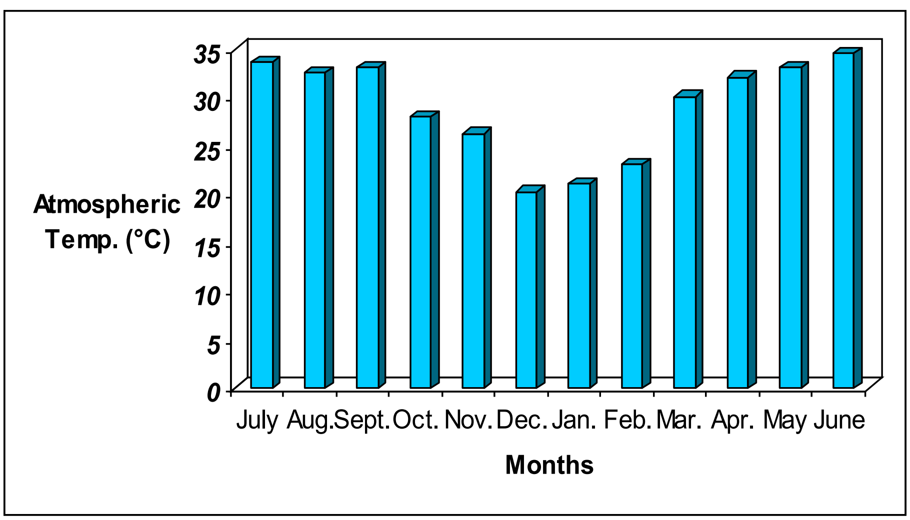

Fig: Atmospheric Temp. Shows

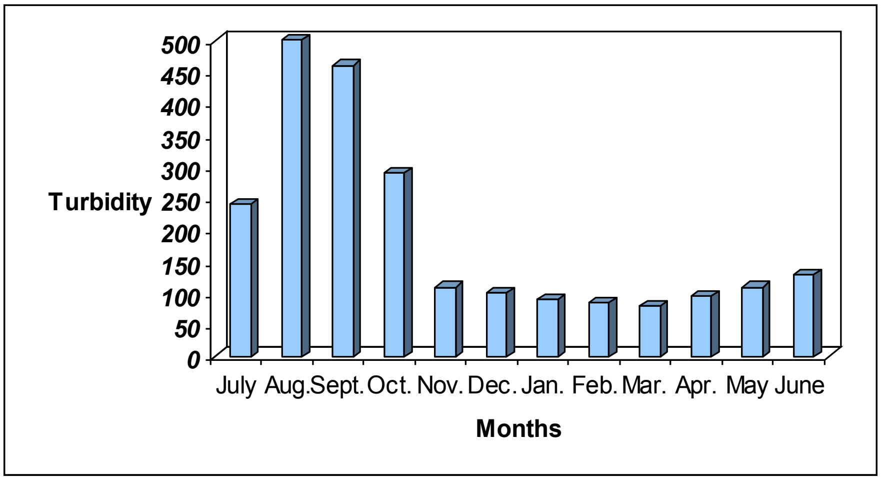

Fig: Turbidity

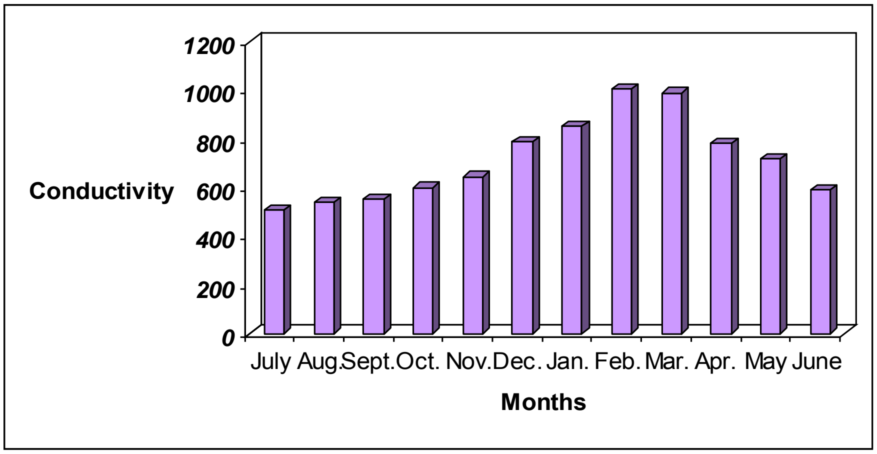

Fig: Conductivity.

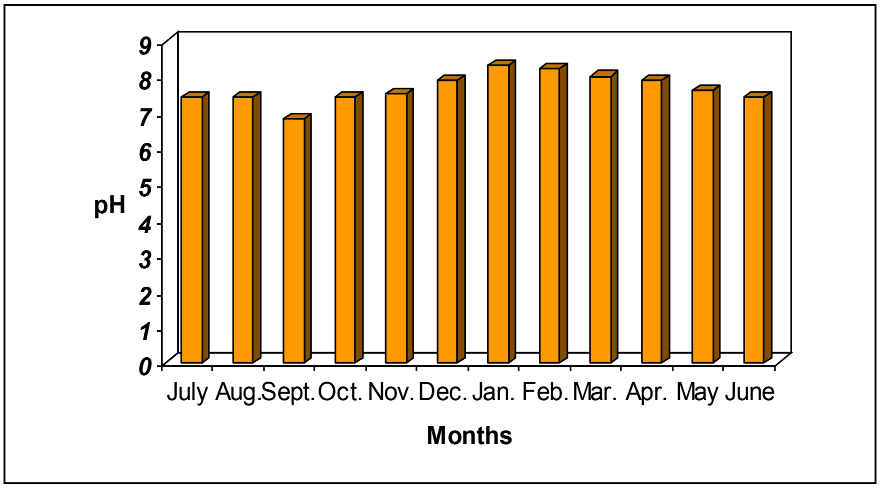

Fig: Water Temp.P[H]

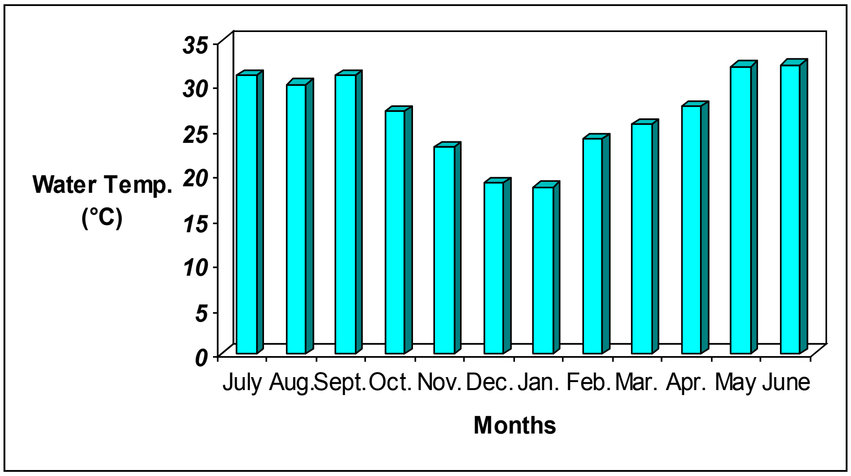

Fig: Water Temp.

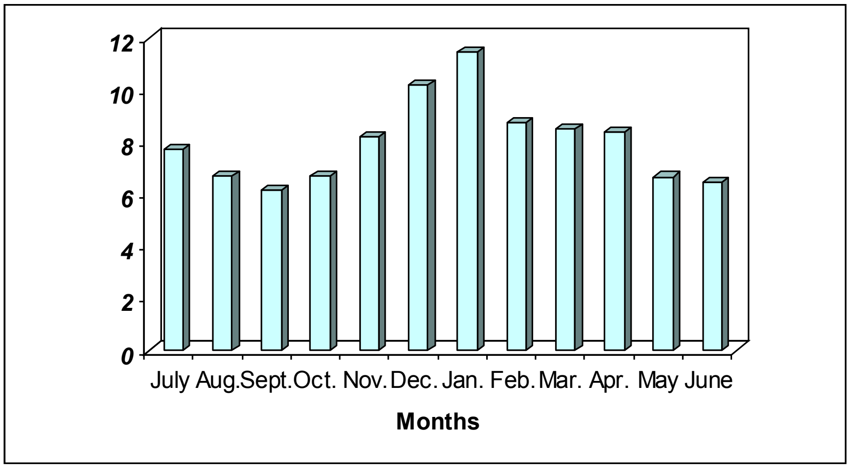

Fig. DO_2(mg.1^{-1})

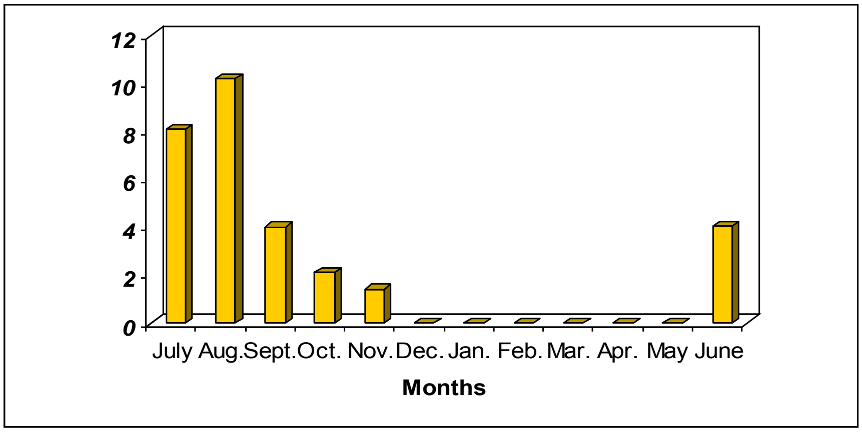

Fig. FCO_2(mg.1^{-1})

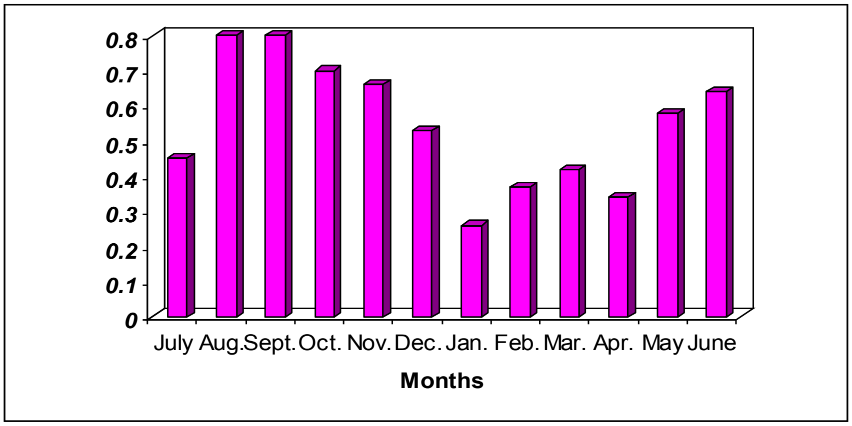

Fig. PO_4—P (mg.1^{-1})

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