Water Soil And Sediment Investigation to Explore Status of Aquatic Ecosystem

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Presented at National Seminar on River Conservation and Management, on 2nd to 4th January 2003 at St. Thomas' College Thrissur, Kerala, Organised by Limnological Association of Kerala.

Abstract

Aquatic ecosystems perform numerous valuable environmental functions like nutrient recycle, ground water recharge, stream flow maintenance, habitat for flora and fauna and provide recreation for people. Structural changes in these complex and dynamic ecosystem will have significant effect on its functioning. These structural changes take place due to unplanned developmental activities without holistic approach on watershed basis. These effects could be cumulative and its assessment is required for remedial measures. To assess these impacts due to river valley project, present study was undertaken in Sharavathi river basin. This is done through water, soil and sediment quality analysis, which is done through analytical methods. The water quality is impaired due to non-point source of pollution. This includes soil erosion and biological coliform at few sites. Soils under study are deficient in nutrients like nitrates, phosphate and sulphates but rich in organic matter. Since the character of sediment is highly dependent on the basin character and soils of catchment having less amount of above mentioned nutrients consequently sediment also. The management options suggested are effective soil erosion control methods based on soil type and appropriate catchment treatment.

Introduction

Aquatic ecosystem depends on various interdependent and interrelated factors that are vital for its existence and play a role in the maintenance of ecological balance. Concern for the declining water quality and impaired ecological conditions in many aquatic ecosystems caused by various anthropogenic activities has necessitated greater need for limnological investigations. In fact the quality of water is of vital concern for the living beings and the estimates of the global values of wetlands ($ 3.2 trillion per year) and rivers and lakes ($1.7 trillion per year) indicate the key importance of freshwater to humans (Costanza et. al. 1997). These estimates suggest that the greatest values of natural aquatic systems are derived from flood control, water supply and waste treatment. The value per hectare is greater for wetlands, streams and rivers than for any terrestrial habitats. The fresh water used either for domestic or for irrigation is not available without cost. In Arizona highly subsidized irrigation water sells for about $0.01 per meter3 and clean drinking water costs $0.37 per cubic meter (Rogers, 1986). In United states drinking water costs between $0.08 to 0.16 per cubic meter (Postel, 1996). Agricultural pesticides contamination of ground water in the United States leads to total estimated costs of $1.8 billion annually for monitoring and cleanup (Pimental et. al. 1992). Erosion related to agriculture causes losses of $ 5.1 billion per year directly related to water quality impairment in the United States (Pimental et. al. 1995).

Sediment, pesticides residue, fertilizer runoff, other non-point sewage with pathogens and nutrients, garbage dumping, encroachment, conversion for agriculture activities and habitat destruction are some major threat to water resources. Perturbation of a freshwater system consists of two sequential events i.e. the disturbance to the system and response of the system to the disturbance. Human-generated disturbance may vary from the application of physico-chemical forces, such as building of dams and changing river flows, to the introduction of exotic biota. The response of biota may vary in relation to the strength of resistance (the capacity to withstand the disturbance) and the level of resilience (the capacity of the biota to recover). Monitoring abiotic and biotic components of streams serves four main aims:

- **To assess the ecological state of ecosystem ·**
- **To assess whether regulated performance criteria have been exceeded ·**
- **To detect and assess the impact of human generated disturbance(s) ·**
- **To assess the response to restoration efforts.**

Since the ecological state and performance of aquatic ecosystem is intrinsically linked with its catchment both structurally and functionally, it is important to know the factors which regulate or controls the flow and ecology of aquatic ecosystem. The function of flowing water ecosystem is strongly dependent on the operation of longitudinal and predominantly unidirectional linkage (upstream and down stream) and on lateral linkage (channel-flood plain). These ecosystems harbour a rich, diverse and unique biota specialized to dwell in the very dynamic environment. Flowing water comprises a very distinctive type of ecosystem with their unidirectionality, their integration with the catchment, high dynamic nature and unique biota. This unidirectionality and high level of spatial and temporal hetrogenity of streams and rivers make the assessment of ecological impacts challenging task and for this an effective special and temporal scale monitoring programme of stream and rivers along with their catchment is very essential.

The catchment land use pattern is linked to the near-by flowing streams and rivers with a mechanism which is unidirectional and not cost effective to restore if quality of aquatic system changes. The major threat to stream and rivers are from soil erosion and agricultural runoff. On commercial farmlands, overstocking, mono-cropping, and the ploughing of marginal lands unsuitable for cultivation has led to soil erosion and desertification. Frequently these practices have been unwittingly encouraged by the ultimately schemes offering subsidies, which made it profitable to exploit the land in the short-term.

Erosion, the detachment of particles of soil and surficial sediments and rocks, occurs by hydrological (fluvial) processes of sheet erosion, gully erosion, and through mass wasting and the action of wind. Erosion, both fluvial and eolian (wind) is generally greatest in arid and semi-arid regions, where soil is poorly developed and vegetation provides relatively little protection. Where land use causes soil disturbance, erosion may increase greatly above natural rates. In uplands, the rate of soil and sediment erosion approaches that of denudation (the lowering of the Earth's surface by erosional processes). In many areas, however, the storage of eroded sediment on hill slopes of lower inclination, in bottomlands, and in lakes and reservoirs, leads to rates of stream sediment transport much lower than the rate of denudation. When runoff occurs, less water enters the ground, thus reducing crop productivity. Soil erosion also reduces the levels of the basic plant nutrients needed for crops, trees and other plants, and decreases the diversity and abundance of soil organisms. Stream sediment degrades water supplies for municipal and industrial use, and provides an important transporting medium for a wide range of chemical pollutants that are readily absorbed on sediment surfaces. Erosion is a fundamental and complex natural process that is strongly modified (generally increased) by human activities such as land clearance, agriculture (ploughing, irrigation, grazing), forestry, construction, surface mining and urbanization. It is estimated that human activities have degraded some 15% (2000 million ha) of the earth's land surface between latitudes 72° N and 57° S. Slightly over half of this is a result of human-induced water erosion and about a third is due to wind erosion (both leading to loss of topsoil), with most of the balance being the result of chemical and physical deterioration (www.gcrio.org/geo/soil.html). Annual soil loss in South Africa is estimated at 300 - 400 million tonnes, nearly three tonnes for each hectare of land. Replacing the soil nutrients carried out to sea by the rivers each year, with nutrients, would cost R1000 million. For every tonne of maize, wheat, sugar or other agricultural crop produced, South Africa loses an average of 20 tonnes of soil. The FAO estimates that the global loss of productive land through erosion is 5-7 million ha/year and 140 million ha of high quality soil, mostly in Africa and Asia, will be degraded by 2010, unless better methods of land management are adopted. (http://www.botany.uwc.ac.za).

In order to explore the status of Sharavathi River (keeping in view the catchment practices) the investigation was carried out through the characterization of water soil and sediment to establish some remedial measures.

Study Area

The Sharavathi river with its catchment 1991 sq. km is surrounded mainly by agricultural and forest lands. To explore the status of the Sharavathi river, water samples from different primary and secondary feeders of the main river were collected. The sampled streams were Sharavathi (Nagara), Sharavathi (1), Sharmanavathi, Haridravathi, Muppanae, Talakalalae, Dam outlet, Reservoir, Hurlihole, Yennahole, Valagare, Nittur, Keshwapura, Nandihole and Sampakai. The soil samples were collected from different locations including the water sampling sites and the sediment samples for the corresponding water sites.

Objectives of Study

Objectives are to explore the physicochemical status of aquatic ecosystem in the Sharavathi river basin by field investigation of the water soil and sediment and to suggest the suitable and implimentable management options. In this regard continuous monitoring of river Sharavathi and its primary and secondary feeders along with the catchment soil and sediment were carried out from December 2001 to March 2002.

Methods Adopted for Qualitative Analysis of Water, Soil and Sediment:

The water samples were characterised using the methods provided by NEERI (National Environmental Engineering Research Institute) and APHA (American Public Health Association). The soil and sediment samples were analysed by the methods given by the UAS (University of Agricultural Sciences). Some variables like turbidity, ammonia, residual chlorine and iron were determined using Tara Water Testing Kit. The Organic Matter in soil and sediment were determined by a conservation tillage fact sheet from United States of America (http://www.akron.ars.usda.gov/fs_field.html).

Result & Discussion

The color of the Sharavathi River and its feeders were found to vary from clear (colorless) to brownish green. Transparency was found in the range of 10 to 284 cms from Valagare or Nandihole to reservoir and the turbidity was found in the range of <5 to 45 NTU. . The most threatened sites due to turbidity were Sharavathi-1, Hurlihole, Yennahole and Valagare. The problem is due to the siltation and poor in the catchment agricultural practices and management. The electrical conductivity was found in the range of 0.014 to 0.1216 ms/cm from Talakalele Dam to Haridravathi and Total Dissolved Solids ranges between 13.77 to 84.3 ppm from Muppane forest area to Haridravathi. The pH in this study was found in the range of 6.8 to 8.25 from Muppani forest area to Sharmanavathi. This pH range is sutaible for the fish eggs and growth of algae, hence may augment the excessive growth of algae and finally algal bloom (7.5 to 8.4, the best range for algal growth). Acidity ranges from 10 to 40 mg/L from Nittur or Dam out let or Muppani forest area to Sharmanavathi and alkalinity varied from 8 to 75 mg/L from Muppani forest area or Talakalale Dam or Reservoir to Sharavathi-1. The values of physicochemical analysis of water samples are given in table-1.

Parameters	**Range values**
Color	Colorless to brownish green
Water tem.	22 – 30^{0} C
Transparency	10 – 284 cm
Turbidity	<5 –45 NTU
E C	0.014 – 0.121 ms/cm
PH	6.8 – 7.5
Acidity	10 – 40 mg/L
Alkalinity	8 – 75 mg/L
DO	5.8 – 7.5 ppm
Total hardness	20 – 126.44 mg/L
Calcium	12 – 90.26 mg/L
Magnesium	8 – 44 mg/L
Chloride	17.04 – 63.9 mg/L
Sodium	4 – 101.4 mg/L
Potassium	0.077 – 9.581 mg/L
Sulphate	0.34 – 22.66 mg/L
Phosphate	0.0 – 0.0699 mg/L
Nitrate	0.0 – 1.6226 mg/L
Iron	<0.3 mg/L
Ammonia	<0.2 – 3.0 mg/L
Residual chlorine	<0.2 mg/L
Fluoride	0.6 – 1.5 mg/L
Biological coliform	Present at Sharmanavathi, Valagare, Keshwapura, Nandihole and Sampakai.

(Table-1 showing all the range values of parameters analysed)

The dissolved oxygen concentration was found in the range of 5.8 to 7.5 mg/L. The total hardness ranged between 20 to 126.44 mg/L from Talakalale Dam to Keshwapura. The Ca concentration was in the range of 12 to 90.26 mg/L from Muppanae forest area to Keshwapura followed by Magnesium concentration 8 to 44 mg/L from the Sharavathi-1 / TD to Haridravathi. In this study chloride varied from 17.04 to 63.9 mg/L from Sharavathi (Nagara) / Valagere / Reservoir / Dam outlet to Sharavathi-1.Sodium concentration was found 4 to 101.4 mg/L from Valagere to

Nandihole and potassium values was found in the range of 0.077 to 9.5081 mg/L varying from Nittur to Haridravathi. The sulphate concentration was found in the range of 0.34 to 22.66 mg/L form Dam out let / Muppanae to Yennahole. The concentration of sulphate was found to decrease from December to March.. Phosphate concentration was found between 0.0 to 0.0699 mg/L from Hurlihole / Reservoir / Talakalale Dam / to Yennahole. Nitrate values were found between 0.0 to 1.6226 mg/L and show the water is suitable for irrigation. In this case the concentration of iron were less than 0.3 mg/L in all the cases. The result shows the values of ammonia was always less than 0.2 mg/L (for drinking water max. 0.2 mg/L and for irrigation 1 mg/L). The presence of coliform at sites Sharmanavathi, Haridravathi, Valagere, Keshwapura, Nandihole and Sampakai shows the anxious condition.

Soil Analysis Result

The soil samples analysed from different locations representing the linkage with the primary and secondary streams of Sharavathi River have physicochemical properties stating the anxious conditions at all the locations sampled. In this study the color of the soil samples were found brownish yellow, reddish brown, dark earthly gray, and light brown. The dark color soils are more productive than light yellow color. The light color of soils may be due to salt accumulations and the red color due to the presence of iron in different forms. The bulk density was found between 0.7862 to 1.3591 mg/cm3 from Nittur to Trimurthimannai and electrical conductivity was found in the range of 0.0176 to 0.1408 ms/cm from Tumri to Sharavathi-1. The moisture content of the study area was found in the rage of 1.2 to12.15% from agricultural field at Adagalale to Sampakai. The evapotranspiration exceeds rainfall for 8 months from November to June and the number of moisture deficient period is about 185 days (ICAR, 1998). The soil pH was found between 6.1 to 7.8 (Sharmanavathi to Yellodi) and is interpreted as optimum quality for plant growth. The acidity of soil was found between 1 to 5 mg/gm, from Nagara / Hosanagara to Sharavathi -1 and alkalinity 1 to 5 mg/gm from Sharmanavathi to evergreen forest. The soil quality analysed are represented below in table-2.

Parameters	Values
Bulk density	0.7862 to 1.3591 gm/cm^3
Moisture content	1.2 to 12.15 %.
Electrical conductivity	0.0176 to 0 .1408 ms/cm
pH	6.1 to 7.8.
Acidity	1 to 5 mg/gm
Alkalinity	1 to 5 mg / gm.
Chloride	0.426 to 3.62 mg/gm.
Calcium	1 to 17.2 m eq./100gm

Parameters	Values
Magnesium	0.4.8 m eq./100gm.
Sodium	0.004 to 0.182 mg/gm
Potassium	0.005 to 0.280 mg/gm.
Sulphate	0.160 to 1.269 mg/gm.
Nitrate	0.0 to 0.0001 mg/gm
Phosphate	0.00003 to 0.00085 mg/gm
Organic matter	< 1% to >4%
Organic carbon	nil to >2.32%.

The calcium content was found ranging between 1 to 17.2 m.eq. / 100gm of soil from Yennahole to Island near Holebaugle. The magnesium content in this study ranged between 0.4 to 7.8 m.eq. /100gm of soil from Trimurthimanni to Haridravathi. The reason for low exchangeable magnesium content in these soils may be due to heavy leaching losses of magnesium in well-drained soils due to heavy rainfall (Gopal Rao and Rajshekhara 1965). . Most of the soils in Dakshina Kannada and Malnad districts are deficient in available calcium and magnesium (Ananathanarayana et. al. 1986). Sodium and potassium content were found between 0.004 to 0.182 mg/gm (from Haridravathi to agricultural field at Yellodi) and 0.005 to 0.280 mg/gm (from Sharavathi to Nagara). The sulphate content of soils was found between 0.160 to 1.269 mg/gm from Nagara to agricultural field at Yellodi and the reason for less content may be high solubility and dry status of soil. In this study the content was between 0.00003 to 0.00085 mg/gm from Trimurthimannai to Yennahole. The pH of soil was found favourable (6.1 to 7.8) for the maximum avaibality (between pH 6.5 to 8.0) of phosphorus, but availability of phosphorous is in two forms one being adsorbed phosphorous and other in solution and soils with high organic matter content hold less quantities of phosphorous adsorbed and that in solution due to soil erosion and runoff washed away. The nitrate content was found in very less concentration ranging between non-detectable to 0.0001 mg/gm. inhibited. Since the nitrogen fixation is dependent on the water holding capacity or moisture content of soil, the rate of oxygen influx and pH range 6.6 to 8.0 (favourable range for nitrogen fixation). In this case the moisture content is low but the pH range favors. The role of oxygen is to provide the optimum conditions to nitrifiers to works. The soil water is considered only 50% to 67% of the water holding capacity, so the available water is less to fix nitrogen. . In catchment the organic matter was found between <1 to >4% from Sampakai, Nittur and near Dam outlet to Yellodi, Tumri, on the way to Yennahole, Hosnagara, Haridravathi, Muppane, Evergreen forest near dam, Island near Holebaglae, Thrimoorthimanai, Sharavathi (1), Sharavathi (2), Sharamanavathi, Haridravathi, Hurlihole, Yennahole. The soil near reservoir was found to have lowest organic matter.

Sediment Quality Analysis

The moisture content of sediment samples was found in the range of 8.80 to 37.702% from Sharavathi-1 to Valagere. The bulk densities were found between 0.783 to 1.475 gm/cm3, from Nittur to Haridravathi showing the bottom condition soil to rocky. and EC values were found between 0.0211 ms/cm to 0.0403 ms/cm, showing low EC values, which can result in least nutrient transfer, complexation and exchange of elements. The sediment quality results are given below in table-3.

Parameters	Range values	Parameters	Range values
PH	6.37 – 7.39	EC (ms/cm)	0.0211 – 0.0403
EC (ms/cm)	0.0211 – 0.0403	Moisture content (%)	8.8 – 37.7
Bulk density gm/cm3)	0.783 – 1.475	Acidity (mg/g)	2 – 4
Alkalinity (mg/g)	1 – 3	Calcium (meq/100g)	1.08 – 7.6
Magnesium (meq/100g)	0.8 – 5	Sodium (mg/g)	0.005 – 0.028
Potassium (mg/g)	0.013 – 0.89	Sulphate (mg/g)	0.191 – 0.68
Phosphate (mg/g)	0.00024 – 0.001	Nitrate (mg/g)	ND – 0.0007
Organic matter (%)	2 – more than 4		

The pH varied between 6.37 to 7.39 from Yennahole to Nagara (Sharavathi). The pH range indicates the least favorable situation for the decomposition. Acidity varied between 2 to 4 mg/gm from Muppanae forest area / Nagara to Reservoir / Valagere / Nittur / Sharavathi-1 and alkalinity varied between 1 to 3 mg/gm from Muppanae / Yennahole to Sampakai / Hurlihole / Haridravathi / Sharmanavathi.The chloride values were found to be 0.92 to 3.33 mg/gm from Haridravathi to Sharmanavathi. The calcium and magnesium values ranged between 1.08 to 7.6 mg/gm from Haridravathi to Sharmanavathi and 0.8 to 5 mg/gm from Yennahole to reservoir respectively. It is highly dependent on the parent materials or rocks. The values of Na and K were found ranging between 0.005 to 0.028 mg/gm from Haridravathi to Reservoir and followed by K, 0.013 to 0.89 mg/gm from Sharavathi-1 to Reservoir respectively. Since the soil having low concentration of these nutrients consequently, the concentrations of these ions were found in fewer amounts. Sulphate varied between 0.191 to 0.68 mg/gm from Sharavathi-1 to Reservoir, phosphate 0.00024 to 0.001 mg/gm from Yennahole to Haridravathi and nitrate non-detectable to 0.0007 mg/gm in most of the cases except Muppanae, Valagere, Nittur and Sampakai. The organic matter was found between 2 to > 4% from Haridravathi to Muppanae forest area. The richness in organic matter is due to the large amount of organic matter in soil. The organic carbon was also found in rich condition ranging from 1.16 to 2.32 % in same place variation.

Conclusion

- Based on the physicochemical and biological analysis of water, soil and sediment of Sharavathi river basin the following conclusion were drawn · The physicochemical and biological analysis of water indicates that most of the variables were within the permissible limit but the few factors like colour, pH, turbidity and biological coliform have found to affect adversely on the water bodies.
- Colour of the sites Sharmanavathi, Haridravathi, Yennahole and Sampakai were found brownish showing the presence of diatoms.
- Turbidity of sites Keshwapura, Handihole and Sampakai were high (more than 10 NTU) showing the increasing trend of dissolved solids · pH (6.8 to 8.25) was found favorable for the fish eggs but simultaneously has a potential to augment the algal growth at all the water sampling sites.
- The biological coliform on the sites of Sharmanavathi, Haridravathi, Valagare, Keshwapura, Nandihole and Sampakai indicated that it was unfit for the consumption of human and animal.
- The soil samples were found rich in organic matter, optimum level for the plant growth and low values for the sulphates, phosphate, nitrates, sodium and potassium. The low nutrients content was due to the removal of upper layer of soil i.e. soil erosion by different means at all the sampling sites.
- The sediment also had the same trend, low level of phosphate, sulphate and nitrate along with high organic matter at the corresponding sites. The bulk densities indicated from soil to rocky bottom condition. The elements Na, K, Ca, Mg were found in normal concentration.

Management Options: watershed approach

- Watershed management is the rational utilization of land and water resources for optimum production with minimum hazard to natural resources. It essentially relates to soil and water conservation in the watershed which means proper land use, protecting land against all forms of deterioration, building and managing soil fertility, conserving water for farm use, proper management of local water for drainage, flood protection and sediment reduction and increasing productivity from all land use. The objective of watershed management should be clearly and precisely spelt to evolve a sustainable approach to conservation and management. This includes.

- To rehabilitate the watershed through proper land use and protection and/or conservation measures in order to minimize erosion and simultaneously increase the productivity of the land and the income of the farmers of the catchment area..
- To develop rural areas in the watershed for the benefit of the people and economies of the region.
- A synergetic approach for all the above along with peoples' participation (defined as employing a method where the associated communities are motivated to function and contribute as a group to perform a predetermined tasks). This is the key factor to success for the soil conservation and management.
- The mobilization of community participation for successful implementation includes:

Awareness

1. **Use of promotional material**
2. **Sharing information**
3. **Attending subject-specific awareness workshops**
4. **Visit to another area to see similar projects already implemented. Involvement**
5. **Participating in the planning stage**
6. **Giving opinions, ideas and alternatives**
7. **Promising contribution and cooperation Learning**
8. **Improvement of knowledge and skills through training**
9. **Fields trials and demonstrations**
10. **Actual implementation**
11. **Application of innovation**
12. **Developing a sense of self-appraisal Organising**
13. **Attending community meetings**
14. **Developing attitude to work as a community**
15. **Resolving conflicts**
16. **Establishing group dynamism and group norms**
17. **Group decision**

The watershed conservation and management plan should be planned out taking into consideration of infrastructure available and socioeconomic status to that specific region. First priority should be given to those which are very close to the main stream or to a public installation where protection is needed like storage reservoir, water intake or diversion dams etc.. The management options of Sharavathi basin are as follows: Since the turbidity of water sampling sites Turbidity of sites Keshwapura, Nandihole and Sampakai were high, hence it is mainly due to the soil erosion in the catchment. This must be minimize adopting the best management practices like

- The use of contour ploughing has the high ability of reducing the runoff in rainy season as it is obivious from a case study that seasonal runoff value of 54% from the untreated catchment was reduced to less than 40% of the rainfall where contour farming was practiced. The corresponding reduction in soil loss was from about 30 tons to less than 20 tones/ha during rainy season.
- Leaving unploughed grass strips between ploughed land;
- Making sure that there are always plants growing on the soil, and that the soil is rich in humus (decaying plant and animal remains). This organic matter is the "glue" that binds the soil particles together and plays an important part in preventing erosion;
- Avoiding overgrazing and the over-use of crop lands;
- Allowing indigenous plants to grow along the river banks instead of ploughing and planting crops right up to the water's edge
- Encouraging biological diversity by planting several different types of plants together;
- Conservation of wetlands of the Sharavathi river basin which will inturn have a great capacity to recharge the ground water, maintain stream flow and augment the availability of soil water to vegetation.

The biological coliform on the sites of Sharmanavathi, Haridravathi, Valagare, Keshwapura, Nandihole and Sampakai indicated that it was unfit for the consumption of human and animal. This needs stopping human and animal waste getting into water bodies immediately.

The soil samples were found rich in organic matter, optimum level for the plant growth and low values for the sulphates, phosphate, nitrates, sodium and potassium at all the sampling sites. The low nutrients content was due to the removal of upper layer of soil i.e. soil erosion by different means. Hence the main culprit is soil erosion and it should be reclaimed through political, social, coordinating with different scientific institutions and extension. The very common remedial measure can be tried that is maintaining plant cover through out the fallow period because these plants slow down water as it flows over the land (runoff) and this allows much of the rain to soak into the ground, plant roots hold the soil in position and prevent it from being washed away, plants break the impact of a raindrop before it hits the soil, thus reducing its ability to erode, plants in wetlands and on the banks of rivers are of particular importance as they slow down the flow of the water and their roots bind the soil, thus preventing erosion.Trees intercept rainfall and reduce its velocity and the force which the raindrops stricke the soil surface. The interception value for Acacia is 15.5 to 20% and for Shorea robusta 14%. For maintaining the other nutrients in soil one can use the sustainable quantity of fertilizer taking into consideration the soil quality and present nutrients.

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