RIVER VALLEY PROJECTS IMPACT ASSESSMENT AND MITIGATION MEASURES

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ABSTRACT:

Large dams and reservoirs in India, as elsewhere, have entailed massive infringements into natural ecosystems and human settlements. Dam proponents affirm that appropriate steps can minimize the impacts of these incursions, including Cumulative Environmental Impact Assessment (CEIA) and preventive / ameliorative measures. CEIA is an effective tool in identifying and evaluating the impacts of the water-affiliated projects like construction of dams and reservoirs etc, commensurate to physical, chemical, biological and socio-economic aspects of the environment and are useful in reducing the adverse consequences of the project, through suitable mitigation measures and monitoring programmes.

Importance of wetland monitoring is determined by the fact that it registers the changes in water, soil, flora and fauna and reflects integrated environmental changes, capable of affecting all biotic components of the environment, including human beings. In this context, a study is being undertaken in Sharavathi river basin (Karnataka) to identify and analyze the qualitative impacts on water and soil, biodiversity and socio-economic aspects in the catchment area due to the construction of Linganamakki dam. A monitoring is being conducted (February 2001 - till date) to evaluate the status of water, soil, vegetation and bird diversity in Sharavathi catchment and suggest appropriate watershed management based on their priority of impacts. A brief description of current status of the river basin, wetland monitoring sites and sampling-analyzing tactics are included in this paper along with suitable mitigation measures (Best Management Practices) for the long- term sustenance of these ecosystems.

INTRODUCTION

Planned development with an integrated approach is necessary to uplift standard of living of people, revive economies and to alleviate poverty. Poorly planned and rapid development can result in disastrous impacts on our basic life-support systems such as clean air and water, productive soil and the earth's rich biotic diversity. Development of river valley projects like dams, reservoirs are one among them, which can cause significant impact on physical-chemical, biological, cultural, bio-diversity, sustainable development and socio-economic components of the environment. Large dams in India, as in several other countries of the world, have been accompanied by significant alterations in the upstream and downstream physical and biological environment (Larry W. Canter, 1985). These development projects often result in unanticipated and undesirable consequences, which may be so drastic as to reduce or even nullify the socio-economic benefits for which the projects are planned. Appropriate steps, including Cumulative Environmental Impact Assessment (CEIA) involving preventive/ameliorative measures can minimize the impacts of these incursions.

There are three essential steps that are necessary for any river valley project to be considered environmentally sensitive:

1. A complete environmental impact assessment should be conducted before the project is considered for clearance, and the results of the analysis should be used to judge the viability and desirability of the project; this would also entail the tentative costing of the impacts and of the preventive/ameliorative measures, as this would have a bearing on the economic/financial viability of the project.

2. If the project is considered viable and desirable on social, economic, environmental, and technical grounds, it is necessary to take preventive and ameliorative measures related to the negative environmental impacts. This requires the formulation of precise and comprehensive workplans, and their implementation.

3. Finally, once the project is commissioned, it is critical to monitor the environmental impacts, and the progress of the preventive and ameliorative measures being taken to address these impacts. At this stage it may even be necessary to redesign the project, if environmental, social, or economic imperatives demand it.

CUMULATIVE IMPACT ASSESSMENT

Cumulative impacts are the additive environmental impacts of a persistent causal agent over time. The term Cumulative Impact Assessment refers to accumulation of human induced changes in valued environmental components including human beings, fauna and flora; soil, water, air, climate and the landscape; the interaction of these factors; and on material assets, and the cultural heritage across space and over time. It reveals the identification, description and assessment of the direct and indirect long-term combined effects of a project (Judith Petts, 1999).

Environmental Assessment is a method used to identify the main impacts a project or activity may have on the environment. The negative and positive consequences of development projects are assessed to provide decision-makers with a holistic and informed opinion based on sound and objective research and analysis. Through an extensive process of consultation with stakeholders and experts, the Directorate of Environmental Affairs (DEA) located at Namibia has developed an Environmental Assessment Policy, which conforms with local and international standards. The same collaborators along with DEA have also developed Environmental Assessment Guidelines for Irrigated Agriculture and for Water Infrastructure.

Environmental assessments -

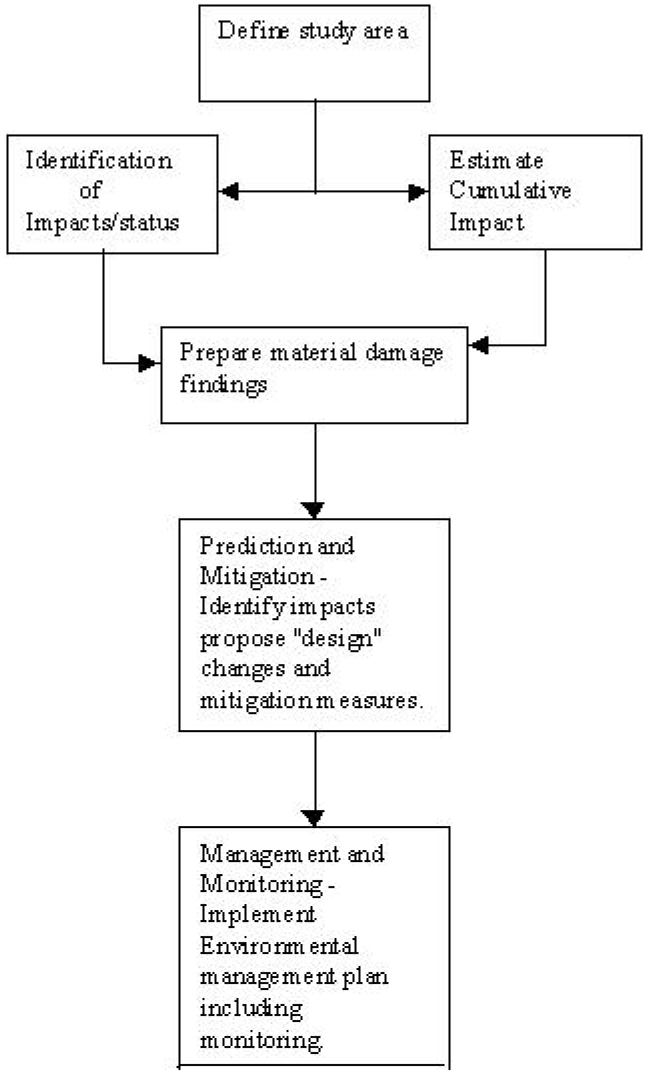
- **are necessary to guide development, both at the strategic level and at the project level;**
- **can serve as early warning systems;**
- **help to identify alternative approaches;**
- **identify cross-sectoral impacts and enable managers to view project proposals in a local, regional and global perspective; and**
- **involve dialogue and interaction between various ministries, NGOs, local authorities, municipalities and the private sector.**

OBJECTIVES

The following investigations were undertaken to assess the extent of impacts due to construction of a dam at Linganamakki for hydro electricity generation in Sharavathi river valley.

- **Monitoring the status of Sharavathi river based on physico-chemical and biological characteristics of water and soil.**
- **To explore an environmentally sound alternative to improve the status.**

FRAMEWORK FOR IMPACT ASSESSMENT



STUDY AREA

This study was carried out in a catchment area to assess impacts due to implementation of river valley project and from the proposed operation, in combination with other existing and anticipated operations.

Study Area:

The Sharavathi is one of the important west flowing rivers of Karnataka, which takes its origin in Western Ghats near Ambutirtha in Tirthahalli Taluk of Shimoga district. The river Sharavathi flows in northwest direction and is mainly utilized for generation of hydro-electric power. Its length is about 128 km and has a total drainage area of 2,771 km2. The river along with its tributaries flows along the rugged terrain of Western Ghats of southwest Shimoga and southeast Uttar Kannada. The river drops to a vertical fall of about 253 m near Jog and it joins the Arabian sea at Honavar in Uttar Kannada (Karnataka State Gazetteer Part I, 1982). This region, by virtue of its geographical sketch, varied terrain and climate supports a rich diversity of flora and fauna

The Karnataka Power Corporation Limited has constructed a dam across the river in 1964 near Linganamakki, which is at present one of the oldest Hydro electric power projects in India. The dam is located at about 14O41'24'' N latitude and 74O50'54'' E longitude with an altitude of 512 m. The total capacity of the reservoir is 152 TMC (Thousand Million Cubicfeet). It has a catchment area of nearly 1991.71 sq.km. It receives water mainly from rainfall and also from the Chakra and Savahaklu reservoirs, which are linked through Linganamakki through a canal. The water from Linganamakki dam flows to Talakalale Balancing Reservoir through a trapezoidal canal with a discharge capacity of 175.56 cumecs. The length of this channel is about 4318.40 m with a submersion of 7.77 sq. km. It has a catchment area of about 46.60 sq.km. The gross capacity of the reservoir is 129.60 cu m.

The construction of the Linganamakki dam has caused submersion of a large area along with loss of biodiversity. The aquatic and soil ecosystems are the major resources under threat. Thus it would be important to assess the cumulative impact of the construction of the dam on the river ecosystem.

IDENTIFICATION OF IMPACTS

In order to identify the impacts and status of the water and soil ecosystems (spatial and temporal changes in its composition) in Sharavathi basins, representative samples were collected and subjected to physico-chemical and biological analysis.

Water Impact Assessment

Monthly water samples were collected at representative sample sites using polyethylene containers through grab sampling method. The representative sample sites were picked so as to represent the entire aquatic ecosystem taking in to consideration number of feeders or tributaries, sources of point and non-point pollution, and outlet for various uses etc.

REPRESENTATIVE SITES

- Location where principal feeder tributary namely Sharavathi (1) (13 °52' 739'' N latitude and 75°3' 903'' E longitude), Sharavathi (2) (13°54' 192'' N and 75° 03' 819'' E), Sharmanavathi (3) (13° 58' 445''N and 75° 06'368'' E), Haridravathi (4) (14° 0'677'' N and 75° 8'490'' E) and Yennehole (10) (14° 1'596''N and 74° 45'339'' E) meets the reservoir.
- Central part of reservoir near Holebagulae (8) (14°4' 54'' N and 75° 53' 864'' E) and near Holedeverbanae (11) (13°59'438'' N and 74°59'337''E) to get a general quality of the water.
- Outlet (7) (14°11'506'' N and 74° 49' 608'' E) from the dam.
- Other minor tributaries like Hurlihole (9) (13° 59' 983''N and 74°51'630''E) and a stream near Haridravathi (13) and (14) with 14° 00' 322''N and 75° 08' 150''E and 14° 00' 922''N and 75° 08' 650''E respectively.
- At Talakalale dam, a balancing reservoir (6) (14°11'587''N and 74°47'210''E) and at Madaenur dam (12) (14°05'937''N and 74o 54'097''E) to get a comparative water quality status over Linganamakki dam.
- Near Muppanae forest area (5) (14° 06'500''Nand 74°47'414''E).

Physico-chemical and biological analyses for the representative samples is being done since February 2001, as per the standard methods prepared and published by NEERI (Indian Standard Specifications [IS: 1050-1983] and [IS: 2490 -1982]) and American public health association (APHA). The parameters include pH, temperature, color, transparency, turbidity, conductivity, total suspended solids, alkalinity, acidity, dissolved oxygen, chlorides, sulphate, total hardness, iron, residual chlorine, fluorides, ammonia, sodium, potassium, nitrates, phosphates and coliform bacteria.

Soil Investigation

In order to determine the general characterization of soil in the catchment, random soil samples of suitable quantity were collected using soil augers, core of size 15 cm x 9 cm and tools like spades or shovels etc. in all landscape elements. Composite samples were taken from an area to a depth of about 15-cm, having the size, shape and orientation of the prospective plot. Large uniform fields were subdivided in to smaller units (not to exceed about 5 ha). Samples were collected from the following representative sites.

REPRESENTATIVE SOIL SAMPLING SITES

Soil samples were collected at the following locations: Yellodi (74^{O}47' 540'' E and 14^{O}06' 497''N), Tumari (74^{O}47' 533'' E and 14^{O}06' 454'' N), Hosanagara (74^{O}47' 523'' E and 14^{O}06' 523'' N), Haridravathi (74^{O}47' 411'' E and 14^{O}06' 563'' N), Adagalale (74^{O}47' 450'' E and 14^{O}06' 616'' N), Muppanae (74^{O}47' 468'' E and 14^{O}06' 652'' N), Holebagulae island (evergreen patch) (74^{O}54' 488'' E and 14^{O}04' 754'' N), Holebagulae (semi evergreen patch) (74^{O}54' 174'' E and 14^{O}04' 865'' N), Sharavathi (75^{O}03' 998'' E and 13^{O}52' 800'' N) and Sharmanavathi (75^{O}06' 488'' E and 13^{O}58' 504'' N).

The physico-chemical and biological analysis of the soil qualities are done as per the standard methods provided by Encyclopaedia of Environmental sciences-15 and Methods manual for forest soil and plant analysis (Kalra, Y.P., and Maynard, D.G., 1991). Physical parameters analysed are bulk density, moisture content and water holding capacity; Chemical parameters analysed are pH, Electrical conductivity, chloride, sulphate, nitrate, phosphorus, potassium, calcium, magnesium, sulphur and total organic carbon; and Qualitative analysis of the microbial population.

Status of water

- Table 1 and 2 gives the Physico- chemical and biological characterization of water quality at various representative sites for the month of July.

TABLE-1

SAMPLE NUMBER	1	2	3	4	5	6	7
PHYSICAL PARAMETER							

Transparency (cm)	23	16	14	8	50	**45**	50
Temperature (oC)	23.8	24	23.9	24.3	23.3	24.1	24.8
EC (ms/cm)	0.03008	0.04416	0.04032	0.0608	0.02048	0.02688	0.02944
Total Suspended Solids (mg/l)	65	78	76	110	40	35	65
Turbidity (NTU)	50	35	30	60	<10	<10	<10
Color *	Brownish	Brownish	Brownish	Brownish	colorless	colorless	Light brown
CHEMICAL PARAMETER							
PH*	7.09	6.89	6.97	6.98	6.95	7.22	6.94
Alkalinity (mg/l)	35	30	35	45	20	20	20
Acidity (mg/l)	5	5	5	5	2.5	2.5	2.5
Chlorides (mg/l)	19.9	14.9	14.9	14.9	14.9	19.9	14.9
Total Hardness (mg/l)	59.5	59.9	76.3	82.2	82.3	49.5	40.9
Dissolvedoxygen (mg/l)	7.7	7.5	7.6	7.7	7.7	7.8	7.7
Sodium (mg/l)	8.31	13.77	11.33	17.66	4.433	5.63	5.924
Potassium (mg/l)	1.134	2.151	1.564	2.151	0.195	0.743	0.860
Sulphate (mg/l)	4.96	11.278	9.47	22.10	7.44	2.93	4.511
Nitrates (mg/l)	ND	ND	ND	ND	ND	ND	ND
Phosphate (mg/l)	0.014	0.0143	0.014	0.0197	0.005	0.0097	0.011
Iron (mg/l)	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Ammonia (mg/l)	0.2	0.2	0.2	2	0.2	<0.2	2
Residual Chlorine (mg/l)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
BIOLOGICAL PARAMETER							
Coliforms *	ND	Present	Present	Present	Present	ND	ND

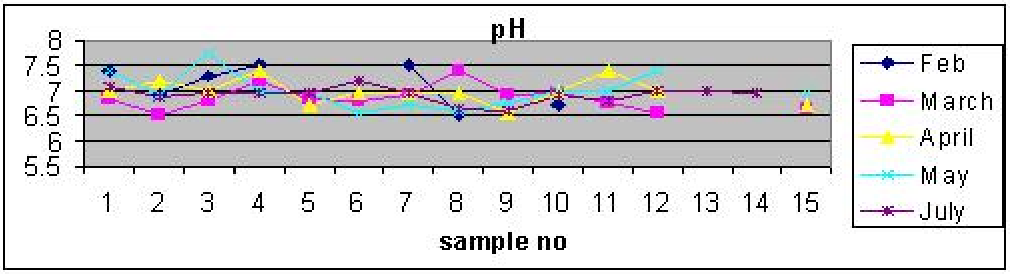
TABLE 2

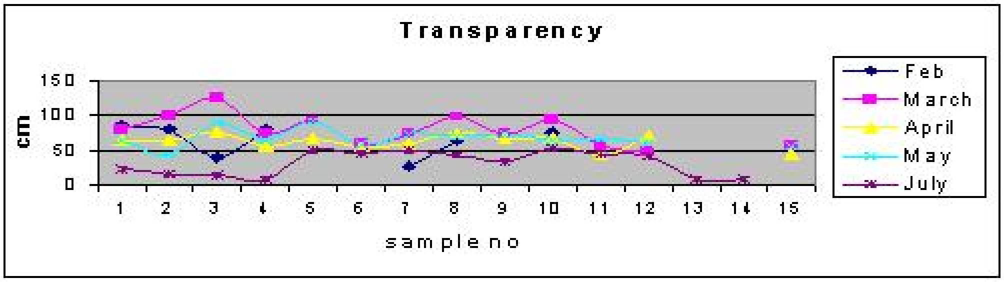
SAMPLE NUMBER	**8**	**9**	**10**	**11**	**12**	**13**	**14**
PHYSICAL PARAMETER							
Transparency (cm)	43	34	**53**	45	42	8	8
Temperature (oC)	26	24.5	23.4	25.5	24.5	24.1	24.4
EC (ms/cm)	0.02496	0.02304	0.02016	0.02528	0.02624	0.05952	0.0672
Total Suspended Solids (mg/l)	55	65	45	55	55	102	108
Turbidity (NTU)	<10	<10	<10	<10	<10	25	75

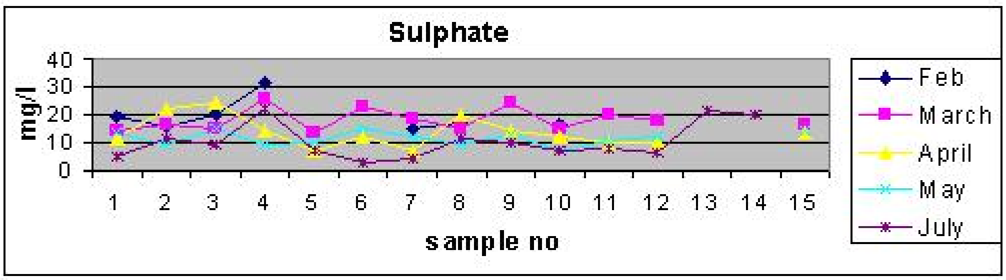
Color *	Light Brown	Light Brown	colorless	Light Brown	Light Brown	Brownish	Brownish
CHEMICAL PARAMETER							
PH*	6.65	6.6	6.93	6.8	6.99	7.01	6.98
Alkalinity (mg/l)	30	20	20	25	25	55	50
Acidity (mg/l)	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Chlorides (mg/l)	14.9	14.9	19.9	14.9	14.9	19.9	24.9
Total Hardness (mg/l)	38.15	54.5	49.5	49.05	43.6	54.5	54.5
Dissolved oxygen (mg/l)	7.7	7.9	8.0	7.7	7.8	7.3	7.4
Sodium (mg/l)	5.82	5.24	4.46	5.708	6.036	18.457	29.2186
Potassium (mg/l)	0.743	0.391	0.2346	0.7039	0.899	1.447	2.5029
Sulphate (mg/l)	11.278	10.15	7.44	7.66	6.76	21.20	20.07
Nitrates (mg/l)	ND	ND	ND	ND	ND	ND	ND
phosphate (mg/l)	0.019	0.01	0.015	0.01	0.019	0.018	0.03
Iron (mg/l)	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Ammonia (mg/l)	0.2	3	1.5	1.5	1.5	3	2
Residual Chlorine (mg/l)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
BIOLOGICAL PARAMETER							
Coliforms *	ND	ND	ND	ND	ND	Present	Present

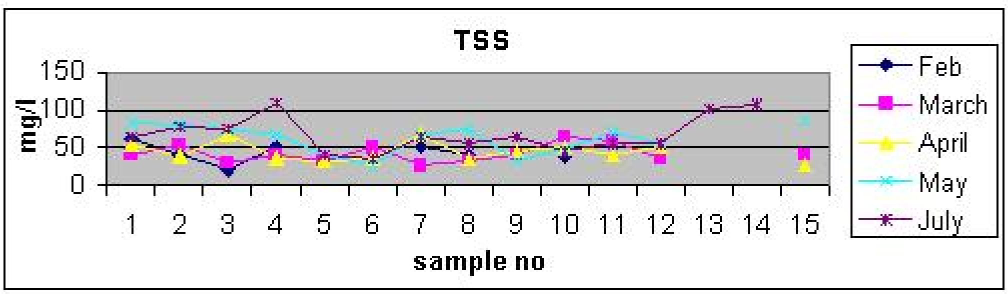
The water analysis results from Feb to July 2001 shows that the pH varies from 6.53 to 7.74, temperature ranges from 23.3 to 31.5OC, dissolved oxygen ranges from 5.0 - 8.0 mg/l, turbidity fluctuates from less than 10 NTU - 75 NTU (mon), electrical conductivity ranges from 0.005 - 0.44 ms/cm, total suspended solids ranges from 21.3- 110 mg/l, alkalinity and acidity ranges from 20-68 mg/l and 2.5 - 20 mg/l respectively, chlorides ranges from 4.9-24.9 mg/l and total hardness ranges from 27.25-81.7 mg/l. Sodium and potassium varies from 4.433-32.02 and nil- 2.5 mg/l respectively, sulphate ranges from 2.93-32.02 mg/l, nitrates and phosphates ranges from nil-0.42 and nil-0.032 mg/l respectively. Concentration of iron and ammonia shows less than 0.3 mg/l and less than 0.2 to 3 mg/l at varies sampling points respectively. Residual chlorine shows less than 0.2 mg/l and fluoride fluctuates between 0.6 and 1.5 mg/l. Color, varies from color-less to brownish color. Monsoon samples contain coliform bacteria at Sharavathi 2, Sharmanavathi, Haridravathi and its near by streams; and it shows nil at remaining representative sampling sites. The Fig 1 shows the variations of various parameters from February to July 2001 at different representative sites.

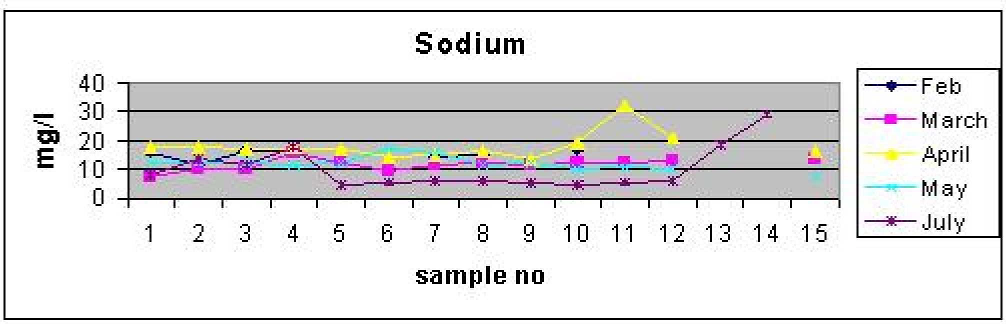
FIGURE-1

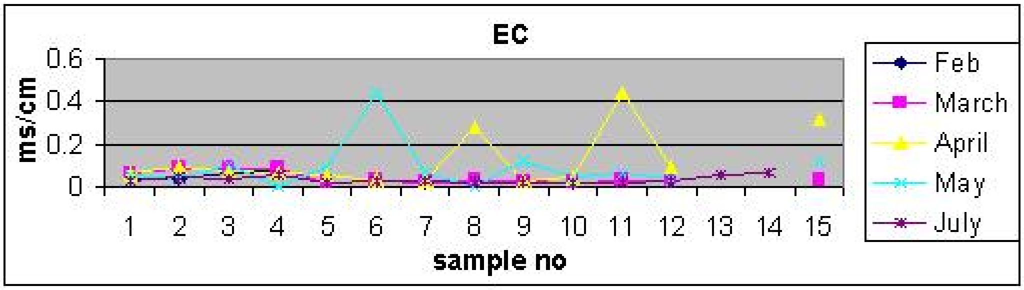

pH
8
7.5
7
6.5
6
5.5
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
sample no
Feb
March
April
May
July

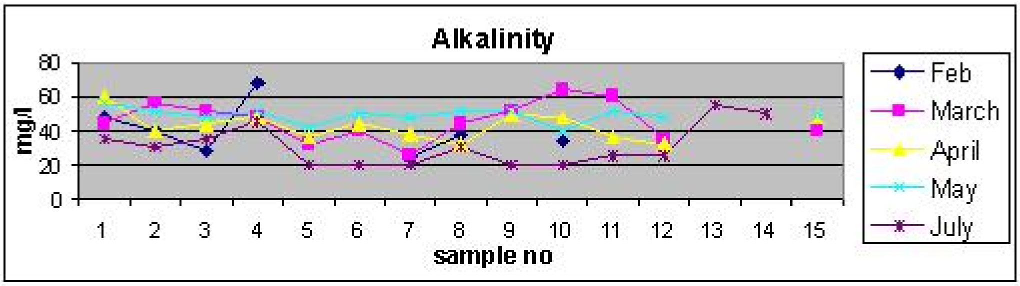

Transparency
cm
150
100
50
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
sample no
Feb
March
April
May
July

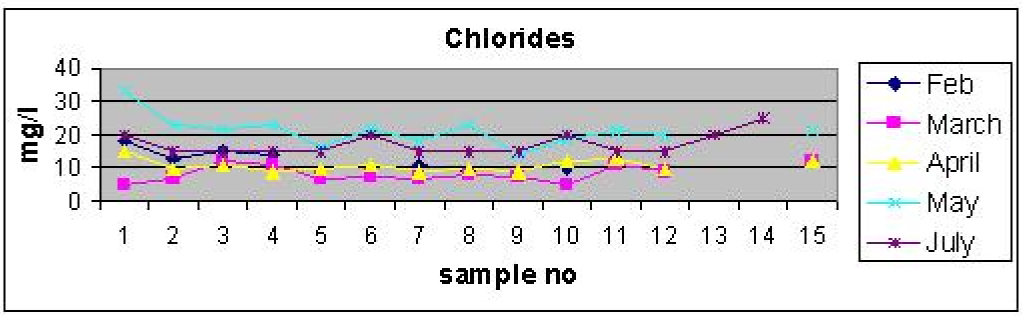

Sulphate
mg/l
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
sample no
Feb
March
April
May
July

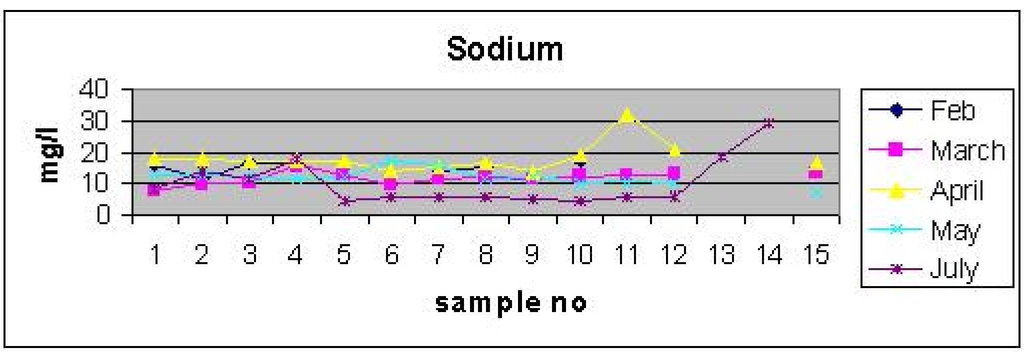

TSS
mg/l
150
100
50
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
sample no
Feb
March
April
May
July


Sodium
mg/l
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
sample no
Feb
March
April
May
July









These results were compared with the standard values provided by NEERI (Indian Standard Specifications [IS: 1050-1983] and [IS: 2490 -1982]), WHO and American public health association. It was found that physical parameters especially turbidity exceeds the limits at Sharavathi 1 & 2, Sharmanavathi, Haridravathi and its near by streams. Brownish color exists almost at all sampling points and increased concentration of total suspended solids (TSS) at Haridravathi and near by streams. These aspects are due to siltation would lead to the loss of reservoir storage capacity. Chemical parameter phosphate exceeds the limit at a stream near Haridravathi and biological parameter coliform bacteria present at Sharavathi 2, Sharmanavathi, Haridravathi and its near by streams and also at

Muppanae forest area. This is mainly due to improper watershed management (agricultural activities along with monsoon erosions in the surrounding areas). Household surveys conducted in this region regarding agrobiodiversity and cultivation practices indicate the use of inorganic fertilisers in Hosanagar area (Linganamakki upstream catchment area). Also, the samples collected during monsoon reveal the pollution due to non-point sources (agricultural activities in the catchment).

ESTIMATE CUMULATIVE IMPACT

There are two general categories of cumulative impact predictions:

1. Qualitative methods.
2. Quantitative methods.

- Empirical equations and statistical correlations.
- Physical process models of the hydrologic system.

Qualitative methods rely heavily on the experience and minimize the need for numerical calculations. Qualitative Results are more general in content and require less detailed information than quantitative methods and hence followed in this cumulative impact study. On the other hand, quantitative methods include a variety of numerical analyses, requiring large amounts of data. In some cases, long-term monitoring is the only way to determine the accuracy of Cumulative Hydrological Impact Assessment (CHIA).

MATERIAL DAMAGE FINDINGS

Material damage is any long-term or permanent change in the available quantity or quality of a water or soil source that will prevent its use or reduce its utility to an existing user within the CIA. In terms of the hydrologic balance, material damage would occur when post developmental operation (dam construction) levels exceed defined limits. These defined limits thus become the criteria or standards against which material damage will be evaluated. The increased public concern for the quality of the Nation's water supplies has led to the establishment of water-quality standards by various regulatory agencies. These standards generally are based on the maintenance and protection of specified water uses such as public and domestic water supply, agriculture, industry, aquatic life, and recreation. After the cumulative impact assessment has been made, the projected impacts for the parameters of concern (projected indicator parameters) are compared to the material damage criteria. Table 3 shows the comparison of material damage criteria for drinking water quality with that of existing standards.

TABLE-3

PARAMETER	OBTAINED VALUES	PERMISSIBLE LIMITS	COMMENTS

PH	6.53-7.74	6.5-8.5	Positive Impact
DO	5-8 mg/l	Should not be less than 3.0 mg/l	Positive Impact
Turbidity	<10 - 75 NTU	Should not be greater than 10 NTU	Negative Impact
Total Suspended Solids	21.3-110 mg/l	100 mg/l	Negative Impact
Color	Colorless - Brown	Colorless	Negative Impact
Alkalinity	20-68 mg/l	200 mg/l	Positive Impact
Sulphates	2.93-32.02 mg/l	150 mg/l	Positive Impact
Chlorides	4.9-24.9 mg/l	250 mg/l	Positive Impact
Sodium	4.433-32.02 mg/l	200 mg/l	Positive Impact
Potassium	Nil-2.5029 mg/l	-	Positive Impact
Nitrates	Nil- 0.42 mg/l	45mg/l	Positive Impact
Phosphates	Nil-0.032 mg/l	0.03 mg/l	Negative Impact
EC	0.005-0.44 ms/cm	50-1500 μ S/Cm	Positive Impact
Ammonia	<0.2- 3 mg/l	Should be less than 0.2 mg/l	Negative Impact
Coliform bacteria	ND-Present	Should be nil	Negative Impact

The physico-chemical and biological parameter analyses indicate siltation [turbidity exceeds the limit (at Sharavathi 1 & 2, Sharmanavathi, Haridravathi and a small stream near Haridravathi), brownish color (almost at all sampling points), higher total suspended solids (at Haridravathi and near by streams)], higher phosphate [at a stream near Haridravathi], ammonia > 0.2 mg/l [mainly at Hurlihole, Yennahole, Haridravathi and a stream near Haridravathi] and coliform bacteria [at Sharavathi 2, Sharmanavathi, Haridravathi and its near by streams and at Muppanae forest area]. Based on these suitable mitigation measures and management strategies are formulated.

RESTORATION / MITIGATION AND MANAGEMENT/ MONOTORING PROGRAMMES

Restoration is required to improve the quality of water and its catchment conditions inorder to ensure sustainable use of wetland resources. The necessary steps to be implemented in restoring watershed area are,

- ***Pollution impediment*: Waste water, solid and semi solid wastes entering in to the waterbody from external sources (mainly agricultural activities at Sharavathi, Sharmanavathi and Haridravathi areas) are to be controlled.**
- ***Reduction in the external loading*: A reduction of the external loading could be achieved by elimination of the total wastewater input to the river through engineered wetlands at Sharavathi, Sharmanavathi and Haridravathi areas where the agricultural wastes and silt are drained.**

As a extension of restoration programme, watershed management practices involving appropriate catchment treatment involving soil conservation measures are essential for protecting land against all forms of deterioration, conserving water for farm use, proper management of local water for drainage, flood protection and sediment reduction and increasing productivity from all land uses. Best management practices (BMPs) proposed in this regard (EPA, 1999) include:

- **Pollution alleviation practices be applied to reduce the engendering of non-point source of pollution (mainly agricultural and storm runoff at Hosanagara) through source reduction, waste minimisation and process control.**
- **Afforestation with inborn species in desolate areas around the wetland (mainly Hosanagara area) to control the entry of silt from run off.**
- **Constructed wetlands for the purpose of stormwater management and pollutant removal from the surface water flows.**
- **On soils with a tendency to crust, management options include planting seeds at shallow depths, protecting the soil surface with mulch or crop residues, maintaining a rough soil surface by not over-tilling seed-beds, keeping the soil surface moist until seedlings emerge, selecting crops such as corn that are able to exert pressure during emergence, planting two to four seeds together to increase the pressure they exert during germination, and using transplants rather than seeds.**
- **Gyration of crops rather than monocultures to reduce the need for N and assist with pest control and help in aeration of soil.**
- **Promoting public education programs regarding proper use and disposal of agricultural and other waste materials.**
- **Monitoring programme**

The purpose of monitoring is to map out the actual environmental impact and the resulting changes in the environmental conditions in the impact area of a project. Regular monitoring of wetland are rudimentary in order to determine and register the changes in water, soil, flora and fauna and reflects integrated environmental changes, capable of affecting all biotic components of the environment, including human beings.

Monitoring also reveals any unpredicted effects of the project thus helping to minimize the adverse impact. The monitoring programme includes;

- **about the effects to be monitored;**
- **about the methods to be used;**
- **dates of sampling data;**
- **the overall length of the monitoring program ;**
- **Reclamation plan.**

The restoration agenda with an ecosystem viewpoint through Best Management Practices (BMPs) and regular monitoring helps in correcting point and non-point sources of pollution. This along with regulations and planning for wildlife habitat and fishes helps in arresting the declining water quality and the rate in loss of wetlands. These restoration goals require profound planning, authority and funding along with the financial resources and active involvement from all levels of organisation (Governmental and Non-Governmental Organisations (NGOs), research organisations, media, etc.) through interagency and intergovernmental processes all made favorable in innovating and inaugurating the restoration programs. Network of educational institutions, researchers, NGO's and the local people are suggested to help restore our fast perishing wetland ecosystem and conserve those at the verge of death by formulating viable plans, policies and management strategies.

CONCLUSION

Field investigations along with laboratory analysis for the representative samples reveal that;

- Physico-chemical and biological analysis show parameters like turbidity (less than 10 NTU to 75 NTU), color (colorless to brownish color), total suspended solids (21.3 - 110 mg/l), phosphate (nil-0.032 mg/l), ammonia (<0.2 - 3 mg/l) and the presence of coliform bacteria mainly at Sharavathi, Sharmanavathi, Haridravathi and near by streams due to improper watershed management (agricultural activities along with monsoon erosion in the surrounding areas).
- Household surveys conducted in this region regarding agrobiodiversity and cultivation practices indicate the use of inorganic fertilisers in Hosanagar area (Linganamakki upstream catchment area). Also, the monsoon samples revealed the pollution due to non-point sources (agricultural activities in the catchment).
- Regular monitoring along with Best Management Practices (BMPs) is suggested for better ecological sustainability and their long-term sustenance by managing and conserving the watershed from point and non-point source of pollution that drained in to it.

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