Water Quality Impact Assessment Study of Krishnagiri Reservoir Project, Tamil Nadu

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ABSTRACT

Water quality impact assessment studies are very much useful in identifying the intensity and magnitude of pollution. It is the overall process of evaluation of the physical, chemical and biological nature of the water. Water Quality Impact Assessments (WQIAs) are tools to evaluate the environmental impacts of a certain proposed development activity on water quality and to determine specific measures for mitigation of those impacts. In the present study water samples from eighteen sampling stations were collected from the upstream side and downstream side of the Krishnagiri Reservoir Project study area apart for the reservoir itself. The analysis had been carried out as per the standards for pH, DO etc., It is observed that agriculture practice, fertilizer application and other man made activities have contributed for the quality variation of the water samples in the study area. This paper describes how water quality impact assessment was done for a reservoir project to bring out the real picture in the upstream as well as in downstream side of the Krishnagiri Reservoir Project study area.

Key Words: Assessment, Development, Impact assessment, Quality, Reservoir etc.

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INTRODUCTION

Water is the most essential and prime necessities of life. India is gifted with river systems and many of these rivers are perennial and some of these are seasonal. Unfortunately deterioration in the water quality from these systems due to anthropogenic activities makes the water unfit for its intended use. The pollutants coming as waste released in into water bodies creates nuisance by the way of physical appearance, odour, taste and render the water harmful to utility. Water pollution involves the release into lakes, streams, rivers, and reservoirs etc, substances that become dissolved or suspended in the water or get deposited upon the bottom and accumulate to the extent of damaging the aquatic system. The chief source of pollution is that increasing use of chemical fertilizers and pesticides letting into the rivers and streams running close to the cities and other lowland are yet another cause (Murugasen, Dhamodhar 2004). Hence, quality impact assessment studies are very much useful in identifying the intensity and magnitude of pollution. The operations involved in water quality assessment are many and complex. During the 1950s, in the early days of modern water quality assessment programme were rarely focused on particular issues. However, the water quality assessment process has now evolved into a set of sophisticated including the use of water chemistry, particulate material and aquatic biota. Therefore the methodology must be chosen carefully to ensure that the water quality assessment objectives are met as efficiently as possible. Water quality assessment is the overall process of evaluation of the physical, chemical and biological nature of the water. This paper describes in detail, how water quality impact assessment was done for a reservoir project where environmental impact assessment is studied will expose the real scenario in the upstream and downstream side of the Krishnagiri Reservoir Project study area which paves way for further improvement.

WATER QUALITY IMPACT ASSESSMENT

The main reason for the assessment of the quality of the aquatic environment has been, traditionally, the need to verify whether the observed water quality is suitable for intended uses. Water quality impact assessment helps to determine trends in the quality of the aquatic environment and how that quality is affected by the release of contaminants, other anthropogenic activities, and/or by waste treatment operations. Water quality impact assessment will include benchmarking of current levels of determinants and the developments likely impacts of these levels in relation to current local scenario. In general, Water Quality Impact Assessments (WQIAs) are tools that are used to evaluate the environmental impacts of a certain proposed development activity on water quality and to determine specific measures for mitigation of those impacts.

OBJECTIVES OF WATER QUALITY ASSESSMENT

Quality assessment should be started with scrutinizing the real need for water quality information. Since water resources are usually put to several competing beneficial uses, impact assessment should reflect the data needs of the various users involved. There are two different types of assessment programmes, depending on objectives have to be met:

- Single-objective purpose, which may be set up to address one problem area only. This involves a simple set of variables, such as: pH, alkalinity and some cations for acid rain; nutrients and chlorophyll pigments for eutrophication; various nitrogenous compounds for nitrate pollution; or sodium, calcium, chloride and a few other elements for irrigation.
- Multi-objective purpose, which may cover various water uses and provide data for more than one assessment programme, such as drinking water supply, industrial manufacturing, fisheries or aquatic life, thereby involving a large set of variables.

ELEMENTS OF WATER QUALITY ASSESSMENT

Types of water quality assessment programmes are numerous and these should be designed or adopted according to objectives set on the basis of environmental conditions, water uses, etc. Once the objectives have been set, a review of existing water quality data, sometimes supported by preliminary surveys, determines the programme. Following the implementation of the various assessment activities an important step which is often underestimated is data interpretation. This should be followed by recommendations to relevant water authorities for water management, water pollution control, and eventually for further necessary action to be taken. There are certain standard elements which are common to all water quality assessment programmes.

Preliminary Surveys to the Study area

When a new programme is being started, it is useful to begin with a small-scale pilot project. This provides an opportunity for newly trained staff to gain hands-on experience and to confirm whether components of the programme can be implemented as planned. It may also provide an opportunity to assess the sampling network and provide indications of whether more samples are needed in order to gain knowledge of the water quality at various points throughout a water body.

In a lake or reservoir, it may be necessary to sample at different points to determine whether water quality can be estimated at a single point or whether the lake or reservoir behaves as a number of separate water bodies with different water quality characteristics. It is also essential to investigate variation in water quality with depth and especially during stratification. Lakes and reservoirs are generally well-mixed at overturn and sampling from a single depth or the preparation of a composite sample from two depths may adequately represent the overall water quality. For groundwater's, it is important during preliminary surveys to confirm whether or not the well casing is perforated, allowing access to more than one aquifer. If this is the case then an alternative site should be sought or measures taken to sample from a single aquifer only.

Selecting Sampling Sites and Sampling Stations

Processes affecting water quality and their influence should be taken into account when sampling sites are selected. A sampling site is the general area of a water body from which samples are to be taken and is sometimes called a macro-location. The exact place at which the sample is taken is commonly referred to as a sampling station or, sometimes, a micro-location. Sampling sites can be marked on a map or an aerial photograph, but a final decision on the precise location of a sampling station can be made only after a field investigation.

Sampling Stations on Rivers: Sampling stations on rivers should, as a general rule, be established at places where the water is sufficiently well mixed for only a single sample to be required. Complete mixing of tributary and main stream waters may not take place for a considerable distance, sometimes many kilometers, downstream of the confluence. If there are rapids or waterfalls in the river, the mixing will be speeded up and representative samples may be obtained downstream. Sampling for the determination of dissolved oxygen, however, should take place upstream of the rapids or waterfall because the turbulence will cause the water to be saturated with oxygen. In such a case, several samples should be taken across the width of the river to allow for the possibility of incomplete mixing. A bridge is an excellent place at which to establish a sampling station, provided that it is located at a sampling site on the river. Furthermore, a bridge is often a hydrological gauging station and, if so, one of the bridge piers will have a depth gauge marked on it, thus allowing the collection of stream flow information at the time of sampling. Usually, a sample taken from a bridge at mid-stream or in mid-channel, in a well mixed river, will adequately represent all of the water in the river.

Sampling Stations on Reservoirs: Reservoirs can be subject to several influences that cause water quality to vary from place to place and from time to time. It is, therefore, prudent to conduct preliminary investigations to ensure that sampling stations are truly representative of the water body. Feeder streams or effluents enter lakes or reservoirs there may be local areas where the incoming water is concentrated, because it has not yet mixed with the main water body and narrow inlets of lakes are frequently poorly mixed and may contain water of a different quality from that of the rest of the water body.

Sampling of Groundwater: Sampling points for groundwater assessment are confined to places where there is access to an aquifer, and in most cases this means that samples will be obtained from existing wells. To describe such a sampling station adequately, it is essential to have certain information about the well, including depth, depth to the well screen, length of the screen and the amount by which the static water level is lowered when the well is pumped. One sample is usually sufficient to describe the water quality of the aquifer. Springs can also be useful groundwater sampling points, provided that they are adequately protected against the ingress of contamination with surface water. Other possible sampling stations are boreholes drilled especially to investigate the features of an aquifer, although these are expensive and would be justified only in particular circumstances.

Timing and Frequency of Sampling

Sampling frequency at stations where water quality varies considerably should be higher than at stations where quality remains relatively constant. The time interval between the collections of samples depends on the water body and its specific characteristics. An interval of one month between the collections of individual samples at a station is generally acceptable for characterising water quality over a long time period, whereas for control purposes weekly sampling may be necessary. If significant differences are suspected or detected, samples may have to be collected daily or on a continuous basis. Individual samples taken at a given station should be obtained at approximately the same time of day if possible, because water quality often varies over the course of the day. However, if detection of daily quality variations or of the peak concentration of a contaminant in an effluent is of interest, sampling at regular intervals i.e., every two or three hours throughout the day will be necessary. It is usual to take samples of groundwater at only one depth. Sampling should be supplemented by occasional mapping to describe the aquifer fully. Sample collection should be frequent enough to enable an accurate calculation of the mean concentrations of the variables included in the quality assessment programme. The frequency of sampling required to obtain a desired level of confidence in the mean values depends on statistical measures, i.e. standard deviation and confidence interval.

KRISHNAGIRI RESERVOIR PROJECT (KRP) - A CASE STUDY

The present study is conducted in the Krishnagiri Reservoir Project study area to assess the water quality. Krishna refers to black and Giri refers to hills. This district is gifted with black granite hillocks and named as Krishnagiri. Krishnagiri was formed as 30th district by the Govt. of Tamil Nadu, which was carved out of Dharmapuri district in the year 2004. Krishnagiri district is bounded by Vellore and Thiruvannamalai districts in the East, Karnataka State in the West, State of Andhra Pradesh in the North and Dharmapuri District in the South. Krishnagiri district is elevated from 300m to 1400m above the mean sea level. Krishnagiri Reservoir Project(KRP) is located 78°11'00" to 78°17'00" of North to 12°22'30" to 12°29'00" Latitude of East and across the river Ponnaiyar near Krishnagiri town. The KRP Command area is located in the valley of river ponnaiyar 3km West of the NH-7 Kanyakumari-Kashmir in the Krishnagiri taluk. The total capacity of KRP is 66.10 Mm^3 which covers the total ayacut of 3642 hectares. There are 26 tanks in the command area out of which 7 fed by left main canal and 19 fed by right main canal, which is given in Table 1.

The villages on the upstream side and down steam side of the project area also forms part of the study area for the present study. The list of the villages taken is as follows: Peyanapalle, Pachiganapalle, Bellarapalle, Periamuttur, Sundekuppam, Thimmapuram, Chowtahalli, Thalehalli, Kundalapatti, Mittahalli, Errahalli, Penneswaramadam, Kaveripattnam, Marichettihalli and Paiyur.

Table. 1 The list of tanks fed by the KRP canals

S.NO.	Tank	Command area (in acres)
	Left main canal	
1.	Mohammed Ghouse Tank	102.48
2.	Thimmapuram Tank	548.01
3.	Malayandahalli Tank	42.20
4.	Thalihalli Tank	290.00
5.	Annankuttai Tank	89.99
6.	Baleguli Tank	102.00
7.	Chinnagoundan Tank	73.58
	Right main canal	
8.	Pudu Eri	64.12
9.	Kurumbaratti Eri	105.41
10.	Gopala Joshiyar Kuttai	27.01
11.	Mittahalli Eri	14.14
12.	Ellukuttai Eri	14.94
13.	Suriyanarayana Eri	152.00
14.	Senguttai Eri	8.79
15.	Muchikan Kuttai	19.54
16.	Mallappan Eri	209.00
17.	Golla patti Eri	29.86
18.	Oddan Kuttai Eri	13.31
19.	Errahalli Eri	54.11
20.	Kalleri	8.77
21.	Nadu Eri	94.96
22.	Manickanar Eri	7.30
23.	Kottaiyur Eri	24.95
24.	Pappan Eri	37.93
25.	Paiyur Peria Eri	133.45
26.	Alamarathu Kuttai	5.40

Source: Register of Tanks, Krishnagiri Division KRP Circle, KRP Dam.

MATERIALS AND METHODS

In order to study the water quality impact and solute dispersion in the KRP, water samples were collected from different locations and sources in the project area during the surveys. For the present study 18 sampling stations viz, upstream side of the reservoir, downstream side of the reservoir, at reservoir were taken. The physio-chemical quality of drinking water was assessed during the month of October 2011 for both surface and groundwater and the same is given below in Table 2. and Table 3.

Table 2. The surface water quality in KRP irrigation system

S.No	Parameters	Downstream				Reservoir	Upstream			
		Mean	SD	Max	Min		Mean	SD	Max	Min
01.	Colour	-	-	-	-	-	-	-	-	-
02.	Odour	-	-	-	-	-	-	-	-	-
03.	Temp	-	-	-	-	-	-	-	-	-
04.	pH	7.60	0.08	7.70	7.59	7.90	8.03	0.26	8.37	7.74
05.	EC	1.30	0.32	1.67	0.95	1.60	1.20	0.18	1.60	0.96
06.	DO	6.00	0.30	6.25	5.35	5.40	7.25	1.30	8.60	5.40
07.	TDS	0.53	0.11	0.60	0.36	0.37	0.50	0.07	0.62	0.39
08.	Cl	73.01	20.90	93.70	45.00	45.00	69.10	16.24	92.75	45.00
09.	Ca	88.82	14.70	112.00	66.50	77.70	67.70	42.60	112.00	16.70
10.	Mg	132.50	31.47	167.00	83.40	88.90	168.00	40.35	224.00	88.90
11.	CO_3	28.90	11.90	46.90	11.90	23.40	42.10	7.00	47.00	23.40
12.	HCO_3	264.50	45.00	338.90	207.00	214.30	227.60	51.35	286.00	150.70
13.	SO_4	21.10	24.30	71.50	4.15	27.75	28.60	30.90	77.40	2.95
14.	PO_4	4.80	1.74	6.65	2.35	6.65	8.75	3.35	12.00	4.25
15.	NO_3	0.40	0.20	0.65	0.12	0.65	0.06	0.01	0.65	0.07

Table 3. The groundwater quality in KRP irrigation system

S.No	Parameters	Groundwater			
		Mean	SD	Max	Min
01.	Colour	-	-	-	-
02.	Odour	-	-	-	-
03.	Temp	-	-	-	-
04.	pH	6.90	0.44	7.40	6.20
05.	EC	0.80	0.60	1.80	0.49
06.	DO	6.50	1.00	7.60	5.20
07.	TDS	1.10	0.42	1.45	0.38
08.	Cl	178.00	121.00	353.80	18.60
09.	Ca	105.50	63.20	156.00	0.00
10.	Mg	355.00	138.25	488.50	127.70
11.	CO_3	28.10	18.00	54.75	7.82
12.	HCO_3	447.90	151.50	563.50	182.40
13.	SO_4	18.75	11.13	34.10	7.12
14.	PO_4	11.75	0.54	12.15	10.90
15.	NO_3	0.16	1.05	3.50	0.67

Care has been taken during the collection of water samples. All the samples were properly named and a record was prepared indicating the sources of the samples, depth of the source and the date of collection. Parameters like DO, residual chlorine, temperature have been made immediately. For collection of water samples the bottle was rinsed thoroughly with water to wash out the local impurities. Totally fifteen water quality parameters were analysed in the field and laboratory as per standard methods for physical, ionic composition and nutrient status by employing simple titrimetric and photometric techniques. The physical parameters like pH is analysed with the help of a digital pH meter and EC, TDS and Dissolved oxygen were analysed using the hydro lab probe. Calcium and magnesium ions were estimated by simple varsenate titrimetric method using EBT indicator. Calcium was estimated by employing the same varsenate titrimetric method using murexide indicator. Magnesium was estimated by calculating the difference between total hardness and calcium hardness. Chloride was estimated by argenometric method. Sulphate was estimated by turbidimetric method using auto analyser. Phosphate was estimated by ascorbic acid method using auto analyser. Nitrite was analysed by sulphanilamide method using auto analyser. Carbonate and Bicarbonate were determined by titrimetric method against acid using phenolphthalein and methyl orange indicator. The parameters and methods employed in the chemical examination were given below Table 4.

Table 4. Parameters, Methods and Standards in the Physico-chemical examination of water samples

S.No	Parameters	Method Adopted	WHO (2003)	Unit
01.	Colour	By sight	-	-
02.	Odour	By smelling	-	-
03.	Temperature	Thermometric	-	°C
04.	pH	Digital pH meter	6.5 – 9.5	-
05.	Nitrate	Ion meter	50	-
06.	Dissolved Oxygen	Azide modification	7.0 to 9.0 mg/L at 20 – 30 °C	-
07.	Total Hardness	Titrimetric	100 - 500	mg/L
08.	Carbonate Hardness	Titrimetric	600	mg/L
09.	Non-carbonate Hardness	Titrimetric	600	mg/L
10.	Calcium Hardness	Titrimetric	100	mg/L
11.	Magnesium Hardness	Titrimetric	150	mg/L
12.	TDS	Hydrolab Probe	600	mg/L
13.	Chloride	Argentometric	250	mg/L
14.	Sulphate	Gravimetric	250	mg/L
15.	Phosphate	Auto analyser	0.1	-

RESULTS AND DISCUSSIONS

The collected samples of both surface and groundwater show considerable variations in its quality and this may be due to several reasons.

Colour: Colour in water may result because of the presence of natural metallic ions, humas, plankton and weeds. Iron oxide causes reddish water and manganese oxide causes brown or brackish water. The water samples of the study area are colourless.

Odour: When water comes into contact with several substances of nature and of human use, then it may change its taste and odour. These substances may be minerals, metals and salts from the soil. Some species of algae also produce substances which affect the taste and odour. Water in the study area is found odourless.

Temperature: The variation in temperature depends upon the variations of the atmospheric temperature and may have more effect directly or indirectly on all life processes. The temperature in the study area was found to be moderate and hence no major variation is observed.

pH: It is the negative logarithm of hydrogen ion concentration, more precisely hydrogen ion activity. The pH increases during day time due to the photosynthetic activity, where as it declines during night due to respiratory activity. pH affects the taste of the water. A pH range of 6.5 to 8.5 is acceptable (USEPA 1974). The lower pH of this range causes corrosion, while the higher range causes taste of water soapy feel. The pH value of the water in the study area ranged from 7.5 to 8.0 and thus reveals that the pH of the water samples is in the desirable range and the samples are slightly alkaline in nature. The variation in pH and Dissolved Oxygen at Downstream, Reservoir, Upstream and Groundwater source in the study area is shown in the figure 1.

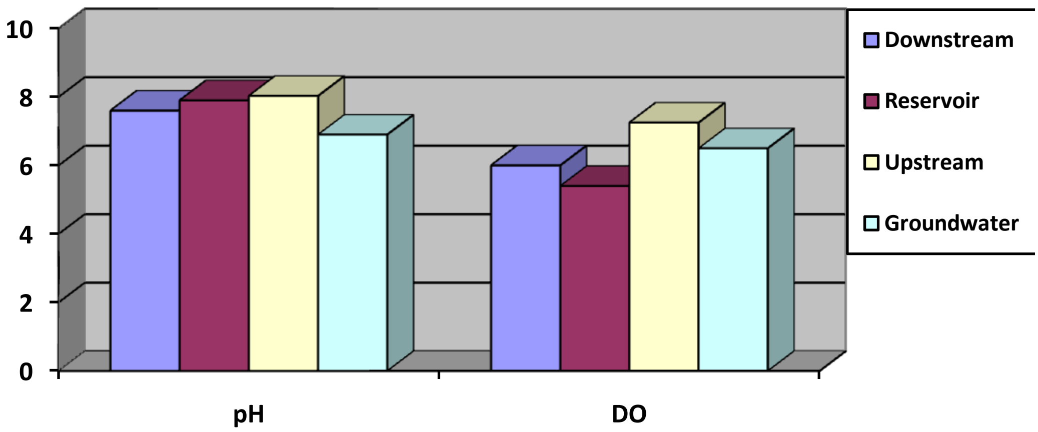

Figure 1. Variation in pH and DO at Downstream, Reservoir, Upstream and Groundwater source at KRP study area

Dissolved Oxygen: DO is one of the most important water quality parameter. It is the amount of dissolved oxygen present in the water. The DO level in the natural and waste water depends on the physical, chemical and biological activities in the water body. The solubility of the O_2 in water is related to pressure and temperature. Good potable water should have the level of saturated DO 7.0 to 9.0 mg/L at 20 – 30°C. In the study area the mean DO level varies and in most of the water samples is not in good amount and the lowest value indicates the present of bacteria. As DO level falls it will have ill effect on aquatic life of the stream.

Chloride (Cl): Chlorine is added to the potable water to eliminate or to reduce the growth of microorganisms in water and to destroy decomposable organic substances so as to reduce the BOD of water. Chloride concentration above 100 mg/L gives taste like salty water.

Calcium Hardness (Ca): Calcium is common constituents of natural water and has important contribution to the hardness of water. In water Ca reaches from the leaching of the rocks. The maximum permissible limit of Calcium hardness according to WHO 2003 is 100 mg/L in drinking water and the values of this parameter ranges from 0 to 100 mg/L in several stations and it is within the limits except in one or two places where on the higher side.

Magnesium Hardness (Mg): Magnesium is also common part of the water and the main sources of magnesium are the rocks. It is considered non-toxic to human beings at the concentration expected in water. The maximum permissible limit of Magnesium hardness according to WHO 2003 is 150 mg/L in drinking water and the values of this parameter ranges.

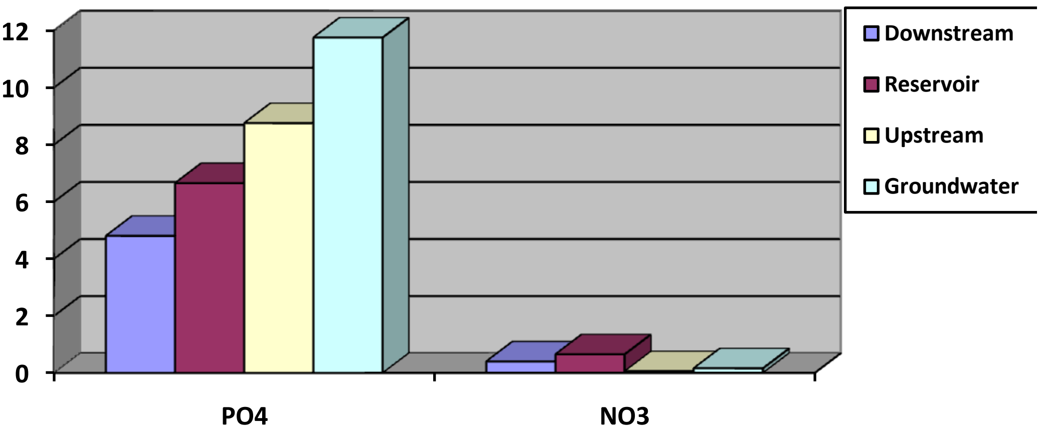

Figure 2. Variation in PO_4 and NO_3 at Downstream, Reservoir, Upstream and Groundwater source at KRP study area

Total Dissolved Solids (TDS): The TDS variation in the surface water along the Ponnaiyar River shows that the level of concentration is higher in the upstream and gets diluted in the impoundment at Krishnagiri reservoir and finally the TDS concentration increases with downstream flow. Though the pattern of water abstraction and reuse in the basin has changed, it has no impact on biological communities downstream, agricultural, or industrial water uses in the basin, as the water quality which we have analysed is within the permissible standards for irrigation also.

Phosphate (PO_4) & Nitrate (NO_3): Nitrate nitrogen is the highest oxidisable from of nitrogen and occurs in trace quantities in surface waters but may attain high levels in some groundwater. Concern about high level concentrations of nitrate in drinking water is growing especially in the rural areas where runoff from nitrate rich fertilizers and animal manures often find its way into the river and streams. The maximum permissible limit of NO_3 in the drinking water is 100 mg/L. The level of phosphate is more at upstream side of the reservoir but the level of nitrate is very low in upstream section. It gradually gets increased with the flow in downstream sections of the reservoir; this shows the level of decomposition of organic matter and at Kaveripattnam its increase towards downstream may the result of agriculture. As for the ground water is concerned the level of phosphate was found to be high in the village Beyanapalle in the immediate upstream of the reservoir and very low in the downstream. The nitrates in ground water was found more in Maharajakadai (0.432 mg/1) but very low in downstream. The variation in Phosphate and Nitrate at Downstream, Reservoir, Upstream and Groundwater source in the study area is shown in the figure 2.

Thus water quality impact assessment investigation reveals that the water is safe for drinking except few stations. Awareness should have been created among the public both in the upstream and downstream villages of the reservoir study area by highlighting the importance of water quality for our betterment.

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