

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 4, April 2017

Water Quality Assessment in Terms of Water Quality Index (WQI): A Case Study of the Chambal River , Kota, Rajasthan

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ABSTRACT: Water quality refers to the chemical, physical, and biological characteristics of water based on the standards of its usage. It is most frequently used by reference to a set of standards against which compliance, generally achieved through treatment of the water, can be assessed. The most common standards used to monitor and assess water quality convey the health of ecosystems, safety of human contact, extend of water pollution and condition of drinking water. Water quality has a significant impact on water supply and oftentimes determines supply options. Water quality index (WQI) provides a single number that expresses the overall water quality, at a certain location and time, based on several water quality parameters. The objective of WQI is to turn complex water quality data into information that is understandable and usable by the public. A number of indices have been developed to summarize water quality data in an easily expressible and easily understood format. The WQI is basically a mathematical means of calculating a single value from multiple test results. The case study is done on Chambal river Kota, Rajasthan, India

KEYWORDS: water, index, quality, Chambal, river, assessment, WQI, supply, mathematical, test

I. INTRODUCTION

Slithering its way through Rajasthan, the Chambal river is a tributary of the Yamuna and forms a major part of the Gangetic channels. In India's largest and driest state, the Chambal river plays a crucial role in agriculture, manufacturing, etc. It is also known for its extensive ravine system, and holds significant historical and cultural value.[1,2]

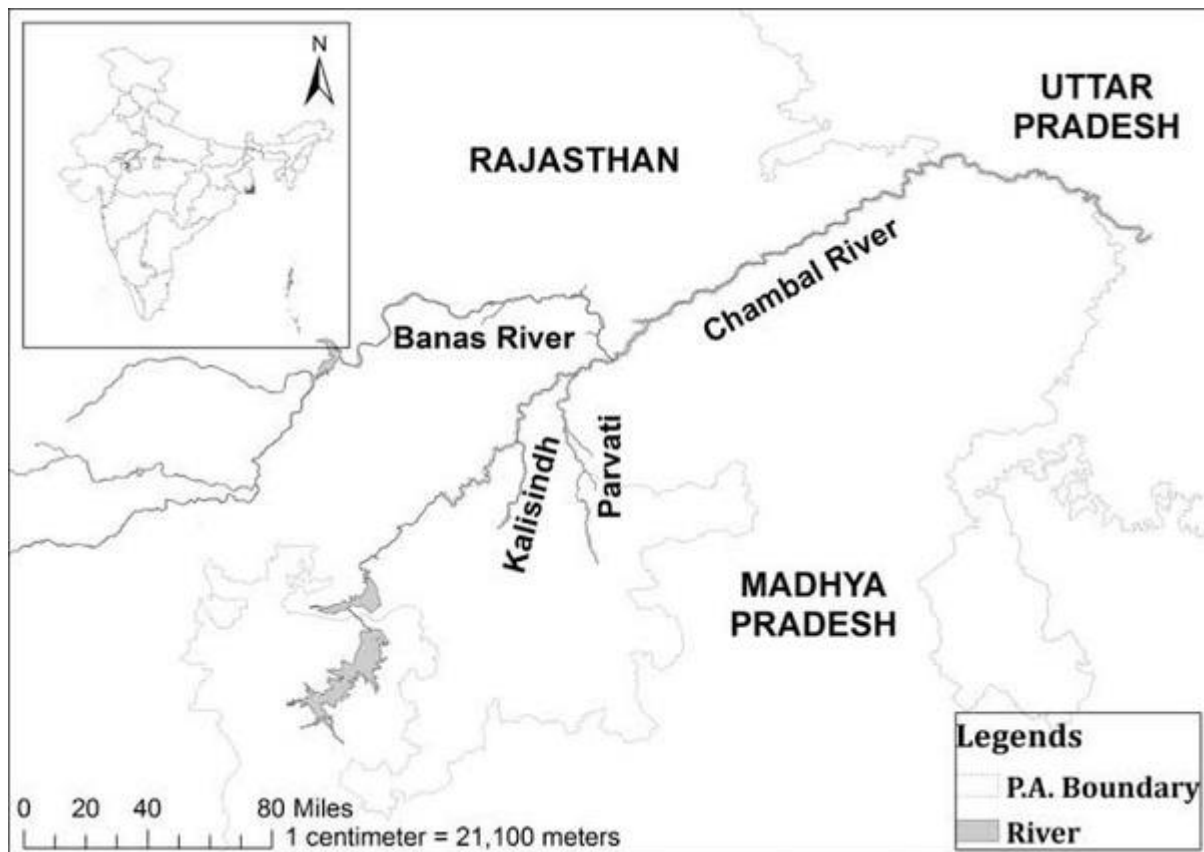
The Hadauti plateau in Rajasthan occurs in the upper catchment of the Chambal River to the southeast of the Mewar Plains. It occurs with the Malwa plateau in the east. Physiographically, it can be divided into Vindhyan scarp land and Deccan Lava (Malwa) plateau. According to Heron (1953), the eastern pediplain, occurring between the Vindhyan plateau and the Aravalli hill range, contains a thin veneer of Quaternary sediments, reworked soil and river channel fills. At least two erosional surfaces can be recognised within the pediplain are the Tertiary age. The Vindhyan upland, the adjoining Chambal valley and the Indo-Gangetic alluvial tract (older alluvium) are of Pleistocene to Sub-recent age. Badland topography is a characteristic feature of the Chambal valley, whereas kankar has extensively developed in the older alluvium.

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The stretch of Chambal river contained in the National Chambal sanctuary (located at 25 degrees 23'-26 degrees 52'N, 76 degrees 28'-79 degrees 15'E) is extending up to 600 km downstream from Kota (Rajasthan) to the confluence of the Chambal with Yamuna river (Etawah). The water quality parameters namely transparency (12.12-110 cm), colour (transparent-very turbid), turbidity (1-178 TNU), electrical conductivity (145.60-884 microS cm(-1)), total dissolved solids (260-500 mg(-1)), pH (7.60-9.33), dissolved oxygen (4.86-14.59 mg(-1)), free carbon dioxide (0-16.5 mg(-1)), total alkalinity (70-290 mg(-1)), total hardness (42-140 mg(-1)), chloride (15.62-80.94 mg(-1)), nitrate (0.008-0.025 mg(-1)), nitrite (0.002-0.022 mg(-1)), sulphate (3.50-45 mg(-1)), phosphate (0.004-0.050 mg(-1)), silicate (2.80-13.80 mg(-1)), biochemical oxygen demand (0.60-5.67 mg(-1)), chemical oxygen demand (2.40-26.80 mg(-1)), ammonia (nil-0.56 mg(-1)), sodium (14.30-54.40 mg(-1)) and potassium (2.10 mg(-1)-6.30 mg(-1)) reflects on the pristine nature of the river[3,4]

Pollution levels in the Chambal, Rajasthan's only perennial river, are rising as the river water treatment project in Kota is moving at a snail's pace. Sewerage drains and waste fall into the river, the lifeline of the coaching city. "Due to pollution in downstream of the Chambal, a crocodile and several small fishes were found dead in the river in Nayapura area a couple of years ago," said Brijesh Vijayvargiya of the Rashtriya Jal Biradari.

Not only drinking water is supplied from the Kota barrage situated on the Chambal, the river caters to canal irrigation in around 2.74 lakh hectares of agricultural area in the Hadoti region.

Vijayvargiya said the Chambal passes through a stretch of around 20 km along Kota city to Keshoraipatan town of Bundi and faces pollution challenges from the densely populated banks on which hundreds of residential colonies have come up over the years.[5,6]

The samples of the Chambal water taken by Rajasthan State Pollution Control Board (RSPCB) reveal pollution levels in the water. KK Jethalia, senior scientific officer, RSPCB, Kota, said the board collects water samples on weekly basis

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from two points in the river on orders of the National Green Tribunal (NGT) and from four points on monthly basis under the national water monitoring programme.

Jethalia said the Chambal river comes under the category of drinking water source. "As per the norms of the Central Pollution Control Board, water source is judged on 4 parameters -- total coliform organisms (maximum permissible number (MPN)/100 ml) should be 5000 or less; pH between 6 and 9, dissolved oxygen (DO) should be 4 mg/l or more, and biochemical oxygen demand (BOD) should be 3 mg/l or less," he said.

"The samples of Chambal water reveal that the quality is poor in downstream in comparison to the upstream from where water is supplied for drinking purposes to the Kota city after filtration," Jethalia said.[7,8]

"Samples taken in October last year from upstream near Akelgarh water filtration plant indicated 13 coliform, 7.73 pH, 1.41 BOD and 5.82 mg DO whereas downstream water sample taken from Kherli phatak reflected 210 coliforms, 5.5 BOD, 6 DO and 7.94 Ph."

BOD is among the vital criteria denoting pollution level which consistently comes higher in downstream where pollution is higher, he said. "If the pollution continues for a long time, then it can change the ecology of the river."

After a long-time demand of environmentalists and city inhabitants for checking pollution, the Chambal River Treatment Project of Kota worth ₹164.37 crore was sanctioned in 2010 and the Urban Improvement Trust (UIT) of Kota was made the agency for its execution.

UIT entrusted the establishment of sewerage treatment plants, lifting stations, sewerage lines, sewage pumping stations and trapping of sewerage drains to two private firms after competitive bidding in 2010.[9,10]

The treatment project was expected to be completed in 2013 but progress of work has been sluggish.

Asked about the progress, executive officer, UIT, CP Shukla said 85 kilometres of sewerage lines out of 282 have been laid in the Kota city and 4 of 22 sewerage drains trapped under the project.

"One sewerage treatment project (STP) in Sajidehra area of Kota city worth 30 million litres a day (MLD) capacity has been established under the project while another STP of 6 MLD capacity at Balita is yet to be set up," he said. "Out of 7 lifting stations (LS) meant to lift sewage water to STPs, three have started functioning."

The project was given extension of 39 months after 2013; though the period is over, the project has not been completed. UIT officials claim completion of around 40% work at the ground zero.

"Around ₹78.12 crore has been spent against the sanctioned amount of ₹164.37 crore in the Chambal pollution treatment project," Shukla said.

Asked about the slow progress of the project, he said, "Private contractors stopped work initially; later they gave assurance to start work. But when firms failed to expedite the project, UIT terminated their service around 2 years ago." UIT officials said rocky strata created hurdle in digging trenches for laying sewerage lines, which proved to be one of the major obstacles in the project work. Also there were financial hiccups as the project failed to get due money on time, said UIT officials.

Meanwhile, green activists have stepped up pressure for completion of the treatment project. Babulal Jaju, state coordinator of People for Animals who filed a PIL in NGT in 2015 on Chambal pollution, said the river is the lifeline of Kota as drinking and irrigation water is supplied through the Kota barrage.

"There seems to be lack of political and administrative will towards the Chambal river conservation, otherwise the project would have been completed by now," he alleged. "The claims of UIT, Kota about progress of the Chambal river pollution treatment project are false and I will soon file a contempt plea in NGT on the issue. The state government should expedite the project work."

UIT officials claim the work will be taken up under the RUIDP (Rajasthan Urban Infrastructure Development Project) phase III. Shukla said tenders for the pending works of the treatment project will be floated soon.[11]

II. DISCUSSION

Water is a vital component of the environment which sustains life on earth. The rapid pace of industrialization, urbanization, agricultural activities and population growth have made all the sources of water either polluted or contaminated globally. Release of treated and untreated industrial effluents in an unplanned manner is one of the major causes of water pollution. Almost 70% of water in India has become polluted due to the discharges of domestic sewages, detergents and industrial effluents into natural water resources e.g. rivers, lakes etc.

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The river holds the largest population of the critically endangered gharial and red-crowned roof turtle. Over the years, the size of this once-mighty tributary has shrunk down. This is owed to the excessive sand-mining and fishing carried out in the highly populated areas surrounding the Chambal river. Due to this, female gharials are forced to migrate and lay their eggs fifteen kilometers away. Sand mining destroys precious natural sand banks that are required by gharials to breed by occupying them with heavy machinery, etc. Hence, gharials no longer have a safe habitat near their homes and have to migrate in search of a better place.[12]

The population boom in Rajasthan has also aided to the problem of Chambal's deterioration. The urgent demand of fresh water for both domestic requirements as well as industrial activities has put to threat the river's life.

Keeping in mind the low-flow rate of Chambal during the dry seasons, several hydroelectric and irrigation projects such as the Rana Pratap Sagar dam have been launched. These sure do help to meet the water requirements of the people, but have add an adverse impact on the flora and fauna around them. Even though one may argue that the scale of such projects is small, to provide the benefits to the people at the grassroots level, the collective impact and pressure of these small projects is large, and it is choking the Chambal river.

The reduction in water levels is a matter of serious concern, because the population of migratory birds that nest exclusively on sand bars, like the Indian skimmer, is at risk too.[13] Chambal, the principal tributary of river Yamuna and the most important river of the Malwa plateau, originates from Janapao hill in M.P, enters Bundi, Kota and then Dholpur districts of Rajasthan and unite with Yamuna, 38 km away from Etawah in U.P. As chambal river flows from different areas of dholpur district, it becomes polluted due to which BOD in the river often rises to 9-14 mg/litre. Roughly 70 mld. of munciple waste is also dumped in chambal river from different areas situated on its bank in Dholpur district. The large population of coastal area of this river is totally dependent on its water. Therefore, it is necessary to assess water quality of Chambal river water at upstream site A (Highway) and downstream site D (near Railway bridge).[14]

In the present observation, water quality with reference to physico-chemical parameters have been assessed at a specific stretch of the water length (approx. 10 kms.) of chambal river. The study has been conducted at the following four sites :

- A. National Highway (Upstream)
- B. Shamshan Ghat
- C. Shergarh Fort
- D. Near Railway Bridge (Downstream)

Water samples for the present investigation were collected from all four experimental sites of the chambal river in Dholpur each after three months interval from October 2005 to July 2006. They were analysed for physico-chemical parameters like temperature, turbidity, electrical flow conductivity (EC), hardness, pH · Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dissolved Oxygen(DO), sulphate, phosphate, chloride, calcium and magnesium as per standard procedures described in APHA. All chemicals used were of AR grade . Double distilled water was used for preparation of reagents.

The temperature of the sample was noted at the sample site during collection and is more important for its effect on the chemistry and biology of organisms in water. The temperature of the water samples ranged from 15⁰C to 32⁰C. All the

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water samples were colourless, odourless and tasteless.

The observed pH values ranging from 7.10 to 7.96 showed that the water samples are slightly alkaline. These values are within highest desirable limit, which is safe range of drinking and growth of plants, as prescribed by WHO. Beyond pH 8.5, the water becomes bitter in taste.

A non significant increase in hardness has been observed in July 2006 i.e rainy season due to dilution of the river but a significant increase in hardness from Oct.2005 to April 2006 may be accounted for reduced availability of chambal water and of untreated sewage in the river. In all the water samples collected, the hardness ranges from 83 to 190 mgL⁻¹. According to some classification, water having hardness upto 75 mgL⁻¹ is classified as soft, 76-150 mgL⁻¹ is moderately soft, 151-300 mg/ L as hard and more than 300 mgL⁻¹ as very hard.⁵ The total hardness above permissible limit causes health hazards and becomes unfit for domestic as well as industrial purposes.[15]

Turbidity ranges from 15.0 to 36.0 NTU. Higher values of turbidity are due to higher concentration of suspended solid particles which decreases the water flow velocity.

As electrical flow conductivity depends on the presence of ions and their total concentration, a non significant increase in conductivity from July 2006 is due to dilution factor whereas a significant rise in it from Oct 2005 to April 2006 is due to low level of chambal water. Electrical conductivity ranges between 0.820 to 0.951 Mhoscm⁻¹ for all seasons. The importance of EC is its measure of salinity, which greatly affects the taste and thus has a significant impact on the uses, acceptance of water as potable.

BOD is the oxygen demand of any system, required for stabilization under biological condition. The value of BOD and COD significantly increases in July 2006 (rainy season) due to influx of more water in the river. Further, a significant increase in BOD and COD from Oct 2005 to April 2006 at downstream site D as compared to upstream site A is due to washing, cattle bathing and domestic sewage of the city. Chemical oxygen demand test allows measurement of a waste in terms of the total quantity of oxygen required for oxidation to carbon dioxide and water.⁷ In this context, COD analysis in surface waters can give the indication of the degree of pollution from municipal or industrial wastewaters. Increasing trends in COD at most of the sites indicate that more wastewaters, treated, untreated or partially treated have been discharged to Chambal river due to population increase and industrial development in the basin.

The values of DO decreases and BOD increases which indicates the rise in organic pollution due to addition of wastes in water. These organic matter undergo degradation by microbial activities in presence of DO, thus decreasing it and increasing BOD.[16]

III. RESULTS

Industries located in the Birlagram Nagda area are discharging their treated effluent in to Chambal River since 1954. At present only 18,500 to 19000 kl./day treated effluent generated mainly from M/S Grasim Industries Ltd. (SFD) Nagda is discharging to Chambal River near Juna Nagda Similarly the untreated domestic waste water of Nagda town about 8000 Kl/day is also mixing to Chambal River with the same nalla. This industrial effluent & Domestic Waste water discharging in to Chambal river is main source of Pollution which contaminate river The River Chambal quality in upstream of Nagda water supply storage barrage is of IS 2296- 1982 Class - 'A' Category while, just after mixing of treated Industrial waste & Domestic waste at Nagda city it becomes normally Class 'E' after that it travels to village Rajgarh about 16 km from Nagda where water quality is found of normally class 'C'.

The BOD and COD values in chambal river is increased due to addition of sewage, small scale industries wastes and rich amount of microbes, discharging their toxic effluents.

Concentration of Sulphate in all the water samples ranged from 17.44 to 33.05 mgL⁻¹. It is within the highest desirable limit prescribed by WHO. Sulphate arises from atmospheric deposition of oceanic aerosols and the leaching of sulphate

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compounds from sedimentary rocks and industrial discharges. Atmospheric precipitation can also add significant amounts of sulphate to surface waters[14]

Present investigation shows the concentration of Calcium in the water samples ranging from 43 to 66 mgL⁻¹. The water above Calcium value 25 mgL⁻¹ is specified as Calcium rich. Thus, the Chambal river water is Calcium rich. Calcium is present in all waters as Ca²⁺ and is readily dissolved from rocks rich in calcium minerals, particularly as carbonates and sulphates, especially limestone and gypsum. The cation is abundant in surface and groundwaters. Industrial as well as water and wastewater treatment processes also contribute calcium to surface waters.

The observed values of Magnesium were between 29 to 46 mgL⁻¹ -maximum in the month of July i.e. Rainy season. Results of present investigation shows that the magnesium content in majority of samples does not exceed the limit as prescribed by WHO. Magnesium is common in natural waters as Mg²⁺ and along with calcium is a main contributor to hardness. Magnesium arises mainly from the weathering of rocks containing ferromagnesium minerals and from some carbonate rocks. Although magnesium is used in many industrial processes, these contribute relatively little to the total magnesium in surface waters.

In the present study, Chlorine in water samples ranged from 47 to 75 mgL⁻¹ being minimum in October and maximum in Rainy season. According to WHO, the maximum permissible limit for Chlorine is 500 mgL⁻¹ and since the values observed in present study are well below this level, it has not imparted the taste to water. It was also found that Chlorine ion concentration bears a conjugate relationship with mineral contents of the respective water samples as Chloride contents increase with increasing mineral. Chloride enters surface waters with atmospheric deposition of oceanic aerosols, with the weathering of some sedimentary rocks and from industrial and municipal effluents and agricultural and road run-off. As chloride is frequently associated with sewage, it is often incorporated into assessments as an indication of possible faecal contamination or as a measure of the extent of the dispersion of sewage discharge in water bodies[15]

This study shows that all the physico-chemical parameters fall within the permissible limit as per standards. The quality of water is safe for domestic and irrigation purposes. Significant increasing trends in COD values at most of the sites suggest that water quality of Chambal river has been deteriorated in terms of organic pollution from industries and from residential areas in the period during which data were obtained. The results of this study will be expected not only to provide public with the recent changes quantitatively in water quality of Chambal river but also to help establish future surface water quality management strategies in the basin.

IV. CONCLUSIONS

Industrial activity along the Chambal basin in Rajasthan has increased the pollution levels of the water by many folds. Unchecked dumping of industrial effluents, chemicals, pesticides, has made the river extremely toxic. Over the years, many environmentalists and reporters have discovered metals and plastic in the stomachs of gharials and fish. But the problem does not stop here. The highly-degraded water continues its journey through Rajasthan and eventually ends as a confluence of five rivers – Kwari, Yamuna, Sind, Chambal and Pahuj; thus, further degrading the quality of other rivers.

As people in Rajasthan continue to indulge in intensive agriculture, and tend to flatten or level ravines along the Chambal basin to try and improve productivity, it only results in the destruction of the ecology which makes it prone to erosion. This further threatens the river.

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The Chambal river forms an integral part of our culture, and it has even been mentioned in the Mahabharata as 'Charmanyavati'. It is not only important to protect the river for the survival of the aquatic life that thrives in it, but also the human lives and livelihoods that depend on it.[16]

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