International Journal of Environment and Health Sciences (IJEHS)
2021, VOL. 3, NO. 3, 11-19
https://doi.org/10.47062/1190.0303.03

A STUDY OF THE JHELUM RIVER'S WATER QUALITY

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Received on: 09.02.2022 **Revised on:** 27.02.2022 **Accepted on:** 10.03.2022

Abstract
The current research focuses on the quality of the Jhelum River, which flows through Srinagar in Kashmir, India. Over the course of eight months (April to November 2021), water samples from various points along the river were collected and tested to assess the water quality based on several factors such as turbidity, taste and odour, total hardness, arsenic, nitrate, sulphate, fluoride, iron, pH, and biological parameters. 7.7 was the highest pH value ever recorded. The lowest turbidity found was 0.9, while the maximum turbidity found was 19.7. The waters had a hardness of 250 mg/l and 375 mg/l, respectively. In majority of the criteria, the water at the site where the wastes were released into the river was found to be more contaminated than the water at the other sites. Almost all the parameters were within the permissible limits except for biological contamination. The focused group discussion and interaction with locals showed an indication of people's knowledge, attitudes, and awareness about water quality, cleanliness, and contamination in the Kashmir Valley. Environmental awareness is the most effective strategy for bringing about societal change for environmental health. Therefore, some awareness programmess were conducted based on the focused group discussions held.

Some awareness programmes were held on a regular basis in the village in question. Further research reveals a shift in community behaviour. Because the process of raising awareness is inclusive, it engages people from all walks of life. Meanwhile, adolescent girls, children, mothers, and the elderly are the true beneficiaries. Changes in behaviour, cleanliness of the environment (environment), lower disease transmission rates, reduced social stigmas and taboos, lower school dropout rates, and effective menstrual hygiene management are all examples of the effects. In a word, we can state that successful implementation of environmental awareness programmes requires active community participation.

Keywords
Jhelum River, Contamination, Kashmir, Water quality.

INTRODUCTION

Water is essential to all living beings and is a significant natural resource. In the past, the water quality in Jammu & Kashmir was practically perfect and devoid of pollution. As a result of anthropogenic activity, the water is now potentially dangerous to human consumption and health. Surface and ground water in the valley have recently been subjected to frequent pollution because of industrial and agricultural activity. Apart from that, residential trash generated by a big population, particularly in places like Srinagar, causes significant environmental and water resource harm. Sewage organics and nutrients combine with water bodies, resulting

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in microbial infestation. Pathogenic disease-causing organisms are important in terms of health since they can cause a variety of diseases if they are not adequately treated. As a result of environmental and human health problems, water quality monitoring is becoming increasingly important (Ali et al., 2007).

Several researchers have observed that industrial, household, and agricultural activity in India have polluted several water basins (Subramanyam, 2006 and Sathware et al., 2007). 80 percent of infections like cholera, amoebiasis, typhoid fever, and giardiasis are caused by contaminated water (WHO, 1997). Several researchers have reported on river pollution's water quality and its effects on human health (Biggs, 1995; Gergel et al., 1999; Caraco et al., 2003; Donohue et al., 2006).The Jhelum River is Kashmir's largest and most important source of water. In Kashmir, the water body provides a major source of electricity, irrigation, and drinking water.It comes from Verinag Spring, which is located at the foot of the Pir Panjal in the Kashmir Valley's southeastern corner. Lidder nallah near hamlet Mirgund at Khanabal, river Veshaw at Sangam in Anantnag, and Sind River at Shadipora in Kashmir Valley are its tributaries. The Kashmir valley has seen a rise in construction activities and vehicular movements during the last decade. The river Jhelum's water quality has deteriorated due to increased population, agricultural activities, and garbage from residential and floating vegetable markets in the valley, rendering it unsafe for human consumption. Pathogens, harmful metals, chemical compounds such as pesticides, herbicides, fertilisers, and other commercial operations and industrial waste can all pollute drinking water. The water is used for irrigation, drinking, and other domestic purposes by the people who live downstream. Furthermore, marketplaces have been shown to be a major source of water pollution. Most plastic products, polythene bags, garbage, and other items come from marketplaces and are then thrown directly or indirectly into rivers or water bodies, causing pollution.

The purpose of this study was to examine certain key water characteristics for the river Jhelum. Turbidity, pH, Fluoride, Iron, Nitrate, Sulphate, Hardness, Alkalinity, Chloride, and *E. coli* were among the physico-chemical and biological characteristics studied.

OBJECTIVES

The objectives of the study were the following.

- To analyse the quality of water at various points of river Jhelum.
- To identify the reasons for the difference in the parameters.
- Based on the study results recommendations or suggestions for improvement in the water quality will be given.

METHODOLOGY

Sample collection

Water samples were taken from the Jhelum River at various locations including Verinag (source), Anatnag, Padgampora, Larkipora, Awantipora, Barsoo, and Srinagar (Table 1, Figure 1). I chose these locations for sampling because Verinag is the source of the Jhelum River and is away from from human settlements, whereas the other sites are heavily populated and have a greater impact on the water quality. Other locations have become contaminated because of increased drainage systems that flow directly or indirectly into the river, but Verinag is free of contamination. Field test kits were used to analyse samples from all the sites on the spot. The samples were collected using the grab sampling method. All samples were collected in 1.5 litre sterile polyethylene bottles, transported to the lab, and processed within 1-2 days.

Table 1: Location of sampling sites.

S. No	Name of Location and Sampling points	Location Code	Latitude	Longitude
01	Verinag	A	33°32’5”	75°14’8”
02	Anantnag	B	33°43’47”	75°8’59”
03	Padgampora	C	33°55’25”	75°0’37”
04	Larkipora	D	33°54’3”	75°0’45”
05	Awantipora	E	33°55’37”	75°0’6”
06	Barsoo	F	33°57’5”	74°58’57”
07	Srinagar	G	34°5’1”	74°47’5”

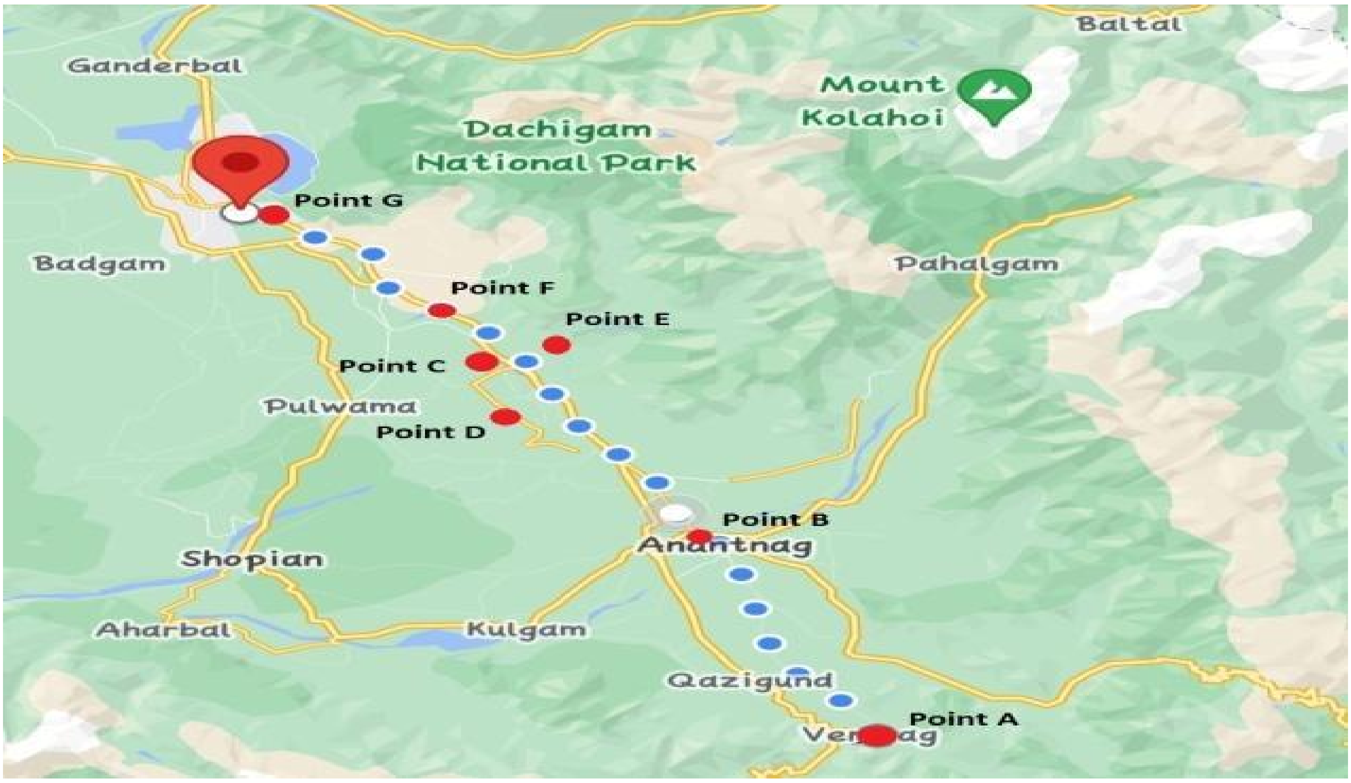

Figure 1:Map showing different areas of sampling

(A) Sample taken from Vering source
(B) Sample taken from Anatnag district
(C) Sample taken from Padgampora of district Pulwama few kilometers away from Srinagar-Jammu national highway
(D) Sample taken from Larkipora Awantipora a nearby village to Awantipora
(E) Sample taken from Awantipora town located in the middle of Srinagar and Anantnag
(F) Sample taken from Barsoo near national highway.
(G) Sample taken from Srinagar city near Rajbag Srinagar.
(H) Awantipoa near Jamia Masjid

Physiochemical and Biological analysis

The samples were collected over the course of eight months, from April 2021 to November 2021 (Figure 2). Standard methods were used to investigate the physiochemical and biological parameters such as Turbidity, pH, Fluoride, Iron, Nitrate, Sulphate, Hardness, Alkalinity, Chloride, E. coli, Turbidity, pH, Fluoride, Iron, Nitrate, Sulphate, Hardness, Alkalinity, Chloride, and *E. coli*. Standard methods such as APHA (2017) and BIS (2012) were used in the analysis. Field Test Kits were utilised for on-the-spot examination, and additional methods included photospectrometric methods, turbidity and pH were measured using electrometric methods (Figure 2).As a result, the results were obtained using either digital metres or the colour comparison approach.

Figure 2: Sample collection at various points and onspot analysis.

Focussed Group Discussion

Focussed Group discussion was carried out among the population in these areas to assess the knowledge, attitude, and awareness of the water quality and contamination prevailing in their area. We also explored the degree of public satisfaction with drinking water quality, public trust of drinking water safety, and public awareness about drinking water problems and solutions.

RESULTS AND DISCUSSION

Water testing is necessary for monitoring water supply operations, ensuring the safety of drinking water, investigating disease outbreaks, validating processes, and implementing preventive measures. To determine the safety of drinking water, water quality testing techniques must be utilised at the source, within a piped distribution system, or at the end user. Water quality surveillance and drinking water quality monitoring are two separate but connected activities.

The Jhelum River, which originates from the famous spring Verinag, is the main supply of water in the Kashmir valley. The river Jhelum is polluted by drainage systems from locals, agricultural runoff, and wastewater discharges from numerous small and large-scale industrial facilities because it passes through several places across the valley starting from Verinag. The River Jhelum was studied, and seven sampling locations were chosen at random, beginning in Verinagupto Srinagar. The samples were examined and compared to the permitted limit defined by the IS: 2296 and the Central Pollution Control Board (CPCB). Table 2 lists the numerous physio-chemical and biological parameters that were examined at these locations, as well as the complete results.

A lot of waste is thrown near the riverbanks by tourists, people living near these areas which is a cause of concern. Figure 3 shows the various forms of waste materials, including polythene bags, organic wastes arriving from adjacent villages and marketplaces. These wastes are accumulated and form waste piles near the river Jhelum banks at all points except Verinag, resulting in soil and river contamination.

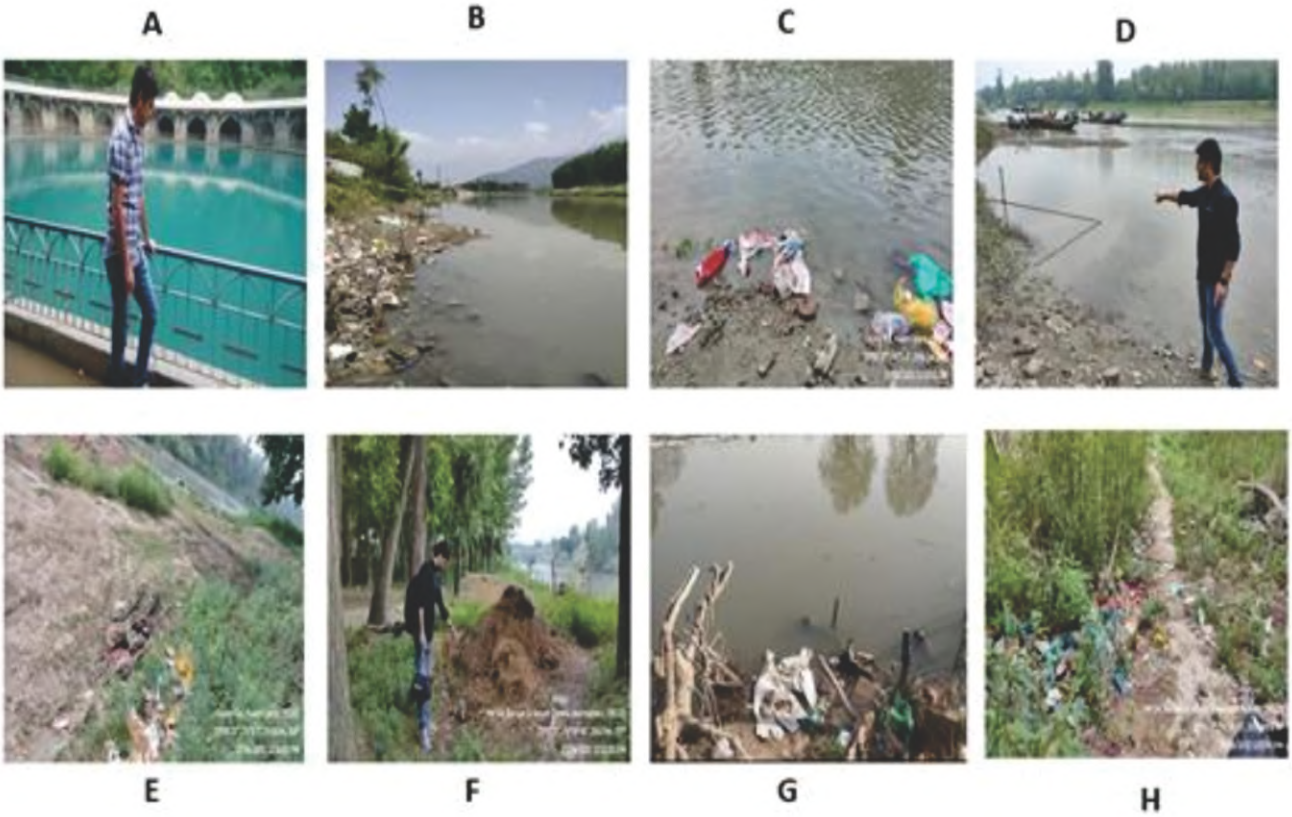

Figure 3: Waste Materials thrown around the riverbanks.

A. Vering source free from any contamination with clean pure water.
B. Wastes accumulated at various areas around river Jhelum at Anatnag district
C. Padgampora of district Pulwama. Organic wastes coming from nearby areas resulting in bacteriological contamination
D. Larkipora Awantipora a nearby village to Awantipora.
E. Awantipora town located in the middle of Srinagar and Anantnag
F. Barsoo near national highway.
G. Srinagar city near Rajbag Srinagar.
H. Awantipoa near Jamia Masjid

Table 2: Physio-chemical and biological parameters analysed at various sampling points along river Jhelum.

District				Anatnag	Anatnag	Pulwama	Pulwama	Pulwama	Pulwama	Srinagar
SOURCE				River	River	River	River	River	River	River
Status-Raw/Treated water				Raw water	Raw water	Raw water	Raw water	Raw water	Raw water	Raw water
Place of collection				Verinag	Anatnag	Padgampora	Larkipora	Awantipora	Barsoo	Srinagar
Sl. No.	**Parameters**	**Units**	**Desirable\ Permissible limits**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1	Iron	mg/l	0.3 - 1.0	0	0	0	0	0	0	0
2.	Nitrate	mg/l	0 - 45	30	40	40	40	45	40	40
3.	Total Arsenic	mg/l	0.1 – 0.10	0	0	0	0	0	0	0
4.	Fluoride	mg/l	1.0 - 1.5	0	0	0.2	0.1	0.2	0.3	0.2
5.	Total Alkalinity	mg/l	200 - 600	220	260	300	300	320	340	340
6.	Residual Chlorine	mg/l	0.2 - 1.0	Raw water	Raw water	Raw water	Raw water	Raw water	Raw water	Raw water
7.	Sulphate	mg/l	200-400	200	210	240	250	260	260	270
8.	pH @ ^{0}C	-	6.5-8.5	7.6	7.7	7.3	7.5	7.6	7.4	7.5
9.	Turbidity	N.T. U	1.0-5.0	0.9	9.8	12.1	12.6	13.1	15.9	19.7
10.	Total Hardness	mg/l	200-600	250	300	325	350	350	360	375
11.	Total Coliform	MPN	Zero	ND	Detected	Detected	Detected	Detected	Detected	Detected
12.	Taste and Odour	-	Unobjectio-nable	UO	UO	UO	UO	UO	UO	UO

i. pH

According to water quality standards, the pH limits should be 6.0 - 8.5. The pH values for all the samples were almost uniform at all points except at certain places it is alkaline. The pH of all the samples was found to be within the BIS range of 6.5 to 8.5. Samples were mostly neutral. The pH from A to G points were normal. The pH limit for drinking water is 6.5 to 8.5. Majority of the samples most of the time showed less than a pH of 8 (Table 2). Similar results were reported by other researchers on the river Jhelum (Khan et al. 2012).Therefore, the pH fluctuated from 7.3 to 7.7. In rivers the occurrence and abundance of components of carbonate system and the pH are determined primarily by current and chemical nature of the substrate (Reid, 1961).Taste and Odour was unobjectionable at all points. Scientists have reported that municipal and domestic wastes can also change the pH of the water bodies (Sithik et al., 2009). The pH greatly affects the biogeochemistry in aquatic ecosystems, such as growth of fishes and aquatic plants. Because most of their metabolic activities are pH dependant, pH has an impact on aquatic species(Wang et al., 2009; Jehangir et al., 2011; Mushtaq et al., 2015).

ii. Turbidity

The samples were tested for their turbidity, and it was observed to be normal and within the permissible limits at Verinag. However, as we descend to Srinagar, it continues to rise. At point A it was below 1 NTU and it was above 5 NTU at points B, C, D, E, F and G but remains below 20 NTU at all points upto point G except A. At point A the turbidity was noted as (0.9), B (9.8), C(12.1),D (12.6), E(13.1), F (15.9), G (19.7) NTU. Hence, turbidity was above permissible limit at all points except Verinag (Table 2). The normal range of turbidity as per BIS is that it should not exceed 5NTU.The higher turbidity values indicate pollution and contamination of the waters (Figure 4).

iii. Flouride

Fluoride was also determined spectrophotometrically. Flourides in the water samples were present within permissible limits. It did not go above 0.5 at all points (Table 2). The permissible limit for fluoride is 0.5-1.5 mg/l as per BIS and WHO. Very low levels of fluorides can lead to deficiency and health effects such as dental caries (Schamschula and Barmes, 1981) and higher levels can lead to bone deformities and mottling of the teeth.

iv. Iron

Iron was also determined spectrophotometrically. Iron in the water samples was zero at all points (Table 2). Hence the water was free from iron content at all points of the study area. The permissible limit for iron is upto 1 mg/l as per BIS and WHO.

v. Hardness

Total hardness of all the samples was found to be within permissible limit. Average total hardness of most of the samples in the study area was found to be higher than 200mg/l indicating that the water is hardwater (Table 2). Total hardness in most cases is always higher than 300mg/l which is the permissible limit by BIS as well as WHO standards. At point A, the value noted was 250mg/l and the highest value was seen at point G with 375mg/l (Table 2, Figure 4). Studies by other researchers such as Mir et al. (2012) reported that the total hardness of the river Jhelum fluctuated between the highest annual mean value of 150 ± 44.33 mg/l and 101±30.46 mg/l.

vi. Alkalinity

It is the capacity of water to neutralize acid. It is a measure of bicarbonates, carbonates and hydroxides present in water. Alkalinity was found to be within permissible limit (Table 2). Total alkalinity of all the samples was not higher than the permissible value (200mg/l and 600mg/l) suggested by BIS as well as WHO. At point A, the value noted was 200 mg/l. The highest values were observed at point G 340mg/l.Mir et al. (2012) reported alkalinity values at Jhelum River with highest annual mean value 150± 35.75 mg/l.

vii. Sulphate

The amount of sulphate was analysed through spectrophotometer as well as on spot using Field Test Kit Sulphate was found within the permissible limits at all sampling points. At point A, sulphate was observed as 200mg/l. The points at E, F and G recorded highest values of sulphate concentrations from 260 and 270 mg/l (Table 2, Figure 4). These higher values may be due to municipal waste effluents and agricultural run off. Qadri et al. (1981) and Shyam (1981) both reported similar results (1988). Researchers have also reported decrease in sulphate concentration during spring due to the metabolic reduction process mediated by sulphate reducing bacteria (Bellos et al., 2004).

viii. Nitrate

Nitrate was estimated using a UV-Visible Spectrophotometer. Nitrogen and phosphorus are important factors in an aquatic ecosystem and play a key role in the productivity of an aquatic habitat. Nitrates were present within the permissible limits at all points throughout the period of study. The maximum permissible limit of Nitrate is 45 mg/l. Almost all the samples had nitrate levels of nearly 40 mg/l.

ix. Arsenic

Arsenic was also determined spectrophotometrically. Arsenic in the water samples were zero at all points. Hence the water was free from any Arsenic content at all points of the study area. It did not go above 0 mg/l at all points. Therefore, there is no arsenic heavy metal pollution in any of the sampling the points tested.

x. Residual chlorine

The value of residual chlorine at all points was 0mg/l. This was probably because all raw samples had been taken and analysed.

xi. Taste &Odour

Taste and Odour was Un-Objectionable at all points.

xii. Total coliforms

Bacteriological contamination was found at all points except at Verinag (Table 2). The reason for the bacteriological contamination may be that at most of the places all the waste products, animal debris, plastic waste, were thrown to the river Jhelum which has resulted in the biological contamination of all samples. Bacteriological parameters were analysed using H_2S Vials. Researchers have reported similar results and contamination from domestic and commercial sewage from Srinagar city (Mehmood et al. 2017). Agricultural activities, indiscriminate use of chemical fertilisers, pesticides, and unplanned development are the factors for the deterioration of water quality in the Jhelum (Mehmood et al. 2017).

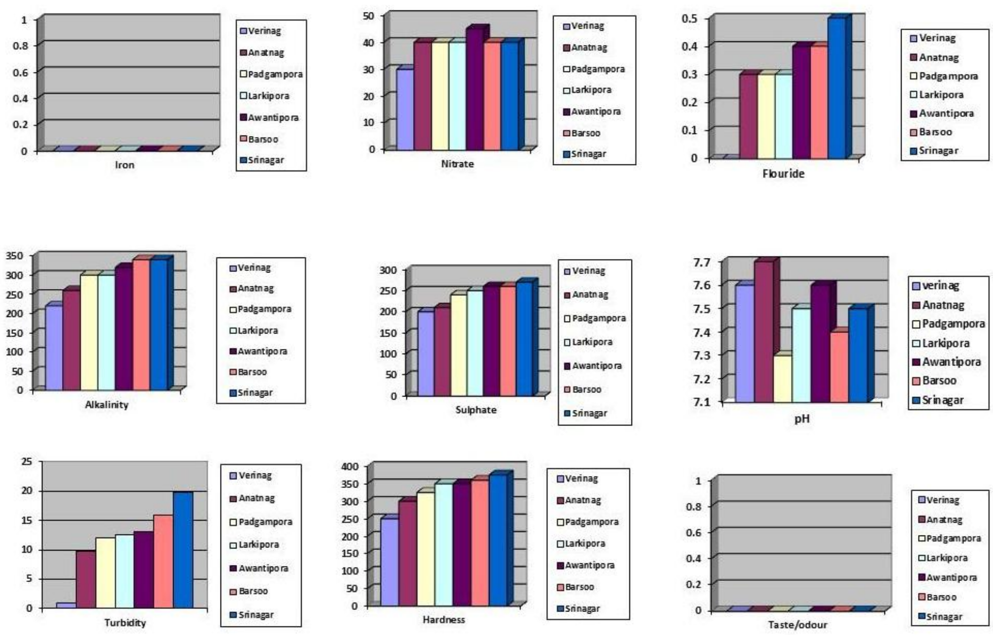

Figure 4: Graphical Representation of Analysed Parameters in Jhelum River.

Following the 2014 floods, the government has given special focus on the river Jhelum. The river has been ignored for far too long, according to the Centre for Science and Environment's report Down to Earth (2017), which states that the organic load is extremely high, and bacteria require more oxygen for respiration, resulting in decreased dissolved oxygen levels. Due to excessive pollution loads, the government had also issued some advice to avoid eating fish.One of the most significant aspects in the operation and growth of an aquatic ecosystem is temperature. It is crucial to aquatic chemistry and life's functioning and activities.The temperature of river Jhelum ranged on an average of 16℃ over the sampling period due to fluctuations the atmospheric temperature. The results obtained in the current study that the geographical location and season have a direct impact on the various physico-chemical and biological characteristics of river Jhelum. The alkaline nature of water could be attributed to the buffering properties of some inorganic substances (Kang et al., 2001). The gradual increase in chloride concentration down the river could be due to the increase in urban land use and due to the addition of some industrial/factory discharge (Livingstone, 1963; Woods, 1965; Allan, 1996). The pH in the river may be attributed to domestic sewage, as the decomposition of the organic matter results in the decrease in the pH value and increase in the carbon dioxide.Similar reports have been reported (Kalal et al. 2021). In rivers the occurrence and abundance of components of carbonate system and the pH are determined primarily by current and chemical nature of the substrate (Reid, 1961). Nitrate occurs in small quantities in unpolluted water but sewage contamination results in a significant increase in its contents. Usually, higher nitrate concentrate concentrations are associated with fertilizer application or human excreta wastes. In the present study we observed bacteriological contamination at all all points except Verinag and higher turbidy values which indicate biological pollution. The water is centainly unfit for human consumption.

FOCUSSED GROUP DISCUSSION

The focused group discussion and interaction with locals on Water Conservation Management and Sanitation gave us an indication of people's knowledge, attitudes, and awareness levels about water quality, cleanliness, and contamination in the Kashmir Valley (Figure 5).Most of the respondents were satisfied with the quality of their drinking water. Age and sex did not seem to play significant roles in the degree of public satisfaction with water quality or in the public perception of water pollution accidents; however, residents in rural areas within a drinking water quality monitoring network seemed more satisfied with their drinking water quality and more aware of drinking water contamination accidents than in areas outside of such a network. Respondents with higher education levels had greater awareness than those with lower education levels with respect to water quality and water pollution accidents. The village heads/panchayat members and some individuals especially the younger population seemed enthusiastic to actively participate in the cleaning of their environment and water bodies. Several Mohalla committees and panchayat members are actively involved in water conservation and contamination prevention, including the river Jhelum although few members were preoccupied with their own companies and have no time for such activities while some of them were not aware of the need for such activiites. There was awareness regarding plastic being the primary source of pollution in water bodies and they wanted a complete ban on plastic bags. They also suggested that trash bins for each household should be advocated.

Fig. 5:Interaction with locals on Water Conservation Management & Sanitation.

The Government launched the Swachh Bharat Mission (Gramin) on 2nd October 2014 to accelerate efforts to achieve universal sanitation coverage, improve cleanliness and eliminate open defecation in India by 2nd October 2019. The program is considered India's biggest drive to improve sanitation, hygiene, and cleanliness in the country. The effectiveness of the programme is predicted upon generating demand for toilets leading to their construction and sustained use by all the household members. It also aims to promote better hygiene behaviour amongst the population and improve cleanliness by initiating Solid Waste Management (SWM) projects in the villages of the country. This is to be bolstered with adequate implementation capacities in terms of trained personnel, financial incentives and systems and procedures for planning and monitoring. The emphasis is on stronger focus on behaviour change intervention including interpersonal communication; strengthening implementation and delivery mechanisms down to the GP level; and giving States flexibility to design delivery mechanisms that consider local cultures, practices, sensibilities and demands (https://swachhbharatmission.gov.in). Moreover, another initative by the Government of India was implemented wherein water quality monitoring and survillence is being given top priority as per the guideline of Jaljeewan mission which says that every household must get clean tap water also.

Awareness Programmes Conducted: Generation of environmental awareness is the most effective strategy for bringing about societal change in terms of cleanliness, environmental health, hygiene, social stigmas, taboos, and soon. It was therefore decided to prepare material and messages for awareness programmess based on the focused group discussions held. Pamphlet distribution, as well as the creation and distribution of suitable information, education, and communication (IEC) material to targeted beneficiaries, were used to raise environmental consciousness in the society. Awareness campaigns were conducted to educate the people regarding environmental pollution, health, and sanitation. Some awareness programmes were organized for this study in order to reach a wider audience and have a better impact (Figure 6).

Figure 6: Awareness programmes conducted regarding environmental pollution.

CONCLUSION

The present study shows that the parameters analysed are within the permissible limits along the river Jhelum. Biological contamination has been observed at all points except Verinag and has caused contamination of the river body posing a great threat to the living forms. Steps should be taken by the Government to always ensure the pristine quality of the river. During focused group discussions, it was observed that there was a considerable level of awareness among most people, and they were also motivated towards helping keep the water clean. Participations in awareness campaigns helped to increase their knowledge, remove misconceptions and further motivate the groups. In addition to the efforts by our governments, inputs and support from both organized and unorganized sectors are required for keeping our rivers clean

ACKNOWLEDGEMENT

Ruhail Maqbool Sheikh would like to thank the CPCB, Jammu and Kashmir for providing testing kits and experimental support.

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