

Analysis of Water Quality Status of the Upper Kosi River of Central Himalaya, India

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Abstract: Due to increasing anthropogenic activities, all the forms of water resources of the world are being polluted continuously and creating a threat for all living organisms. The specific objective of this research paper is to examine the physicochemical and bacteriological water quality parameters of raw water of the Upper Kosi River of the Central Himalaya which water is being used for drinking by the people of the Almora Town and surrounding villages. For this purpose, three years (2018 - 2020) water quality data of raw water of Kosi River were collected from the Jal Sansthan Department Almora and these were examined based on the Bureau of Indian Standard. Out of total 14 water quality parameters, 11 parameters (i. e., pH, alkalinity, arsenic, calcium, fluoride, chloride, total hardness, iron, magnesium, nitrate and sulphate) were found within the range of permissible and acceptable limit of drinking water and 03 parameters (i. e., turbidity, e. coli and total coliform) were found exceeding the acceptable and permissible limit of drinking water. The present study reveals that the raw water of the Upper Kosi River is experiencing a high concentration of faecal coliform because of human activities. Thus, the study suggests that human activities along with the river sites and untreated disposal of sewerage into the river should be strictly banned for the sake of the life of the people.

Keywords: Kosi River, Raw water, Water pollution, Water quality and Uttarakhand

1. Introduction

At present, the whole world is facing the problem of increasing water pollution. Most of the water bodies including rivers, lakes, groundwater, springs, ocean etc are deteriorating and degrading their water quality. The continuous degradation of water quality is leading towards unsafe future of human beings as well as aquatic life because the polluted water affects human health and the aquatic ecosystem. Every year millions of people are losing their life due to waterborne diseases. Due to water pollution, aquatic organisms are disappearing steadily. The pollutant substance changes the physicochemical and organic composition of the water (Khatum, 2017). In developing countries, the problem of water pollution is looming as a big challenge. In these countries, water pollutes in the initial stage at the source of water and which becomes the cause of waterborne diseases in local communities (Gambo, et al.2018). The major sources of water pollution are untreated sewage discharge, industrial waste and surface runoff from agricultural land etc. About 1500 pollutants have been identified as a hazardous substances in freshwater. The use of contaminated water becomes the cause of ill health and death and the use of polluted water also disturbs the human body system (Dwivedi, 2017). Based on source, water pollution can be categorized into two parts: point pollution and non - point source pollution. Point pollution occurs from a fixed or determined source and non - point pollution occurs from uncertain and unfixed sources (WMO, 2012). Singh and Gupta (2017) studied water pollution and found two types of pollutants i. e., organic and inorganic pollutants. Haseena et al. (2017) studied the effect of polluted water on human health and discussed three kinds of waterborne diseases

which are bacterial, viral and parasitic. Owa (2014) studied the causes and management of water pollution. Prevention of pollution and waste minimization approaches can help control water pollution to a great extent. Shelakoti (2016) analyzed the physicochemical characteristics of river Kosi in district Almora to check the potability of water.

The river Kosi is the lifeline for town Almora and about 323 villages. Traditionally, in the Himalayan Mountains the river water is considered clean and safe for domestic uses but the river water in mountains is being polluted due to indiscriminate human activities. The fundamental objective of this paper is to examine the water quality (physicochemical and bacteriological) parameters of the raw water of the Kosi River which is being used for drinking purposes by the people of the Almora Town and more than a dozen surrounding villages.

2. The Study Area

Geographically, the Upper Kosi watershed lies in the Central Himalayan region in district Almora, Uttarakhand. The study area is located in between 29°33'47'' N to 29°52'20'' N latitudes and 79°33'12'' E to 79°48'11'' E longitudes having an area of 463.45 km² (Fig.1). Administratively, the study area is located in two developmental blocks of district Almora namely Hawalbag and Takula. In the study area, there are about 323 villages and one major town (Almora) and many other sub - urban areas distributed in different parts of the study area. The Kosi is a tributary of the Ramganga River and makes confluence with it in Uttar Pradesh state. The Kosi is a sub - basin of the Ganga River.

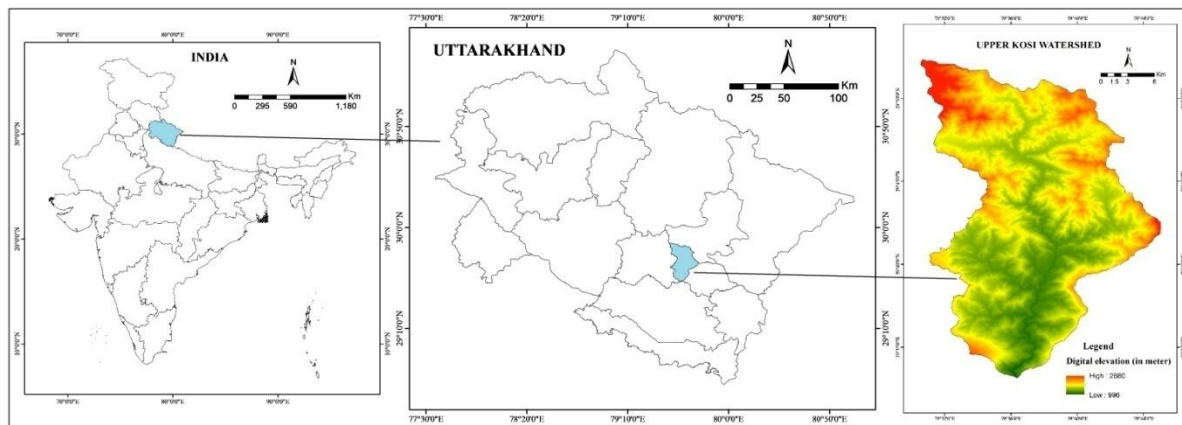


Figure 1: Location map of the study area, viz., the Upper Kosi Watershed in Central Himalaya

3. Methodology

The present study is mainly based on secondary data collected from the Department of Jal Sansthan, Almora. The location map of the study area is constructed using Arc GIS software. For the analysis of water quality, three years (2018 - 2020) monthly raw water quality data of 14 parameters, i. e., pH, alkalinity (as CaCO_3), arsenic, calcium (as Ca), fluoride, chloride, total hardness, iron, magnesium, nitrate, sulphate, turbidity, Escherichia coli, and total coliform were collected from the Jal Sansthan Department Almora. The raw water for water testing was collected by the Jal Sansthan from the drinking water pumping station located near Kosi Town (Plate - 1).

4. Results and Discussion

The water quality data of 14 parameters collected from the Jal Sansthan Department Almora were summarized as presented in Table - 1 which reveals the monthly status of average water quality (2018 - 2020) of the raw water of Kosi River at Kosi drinking water pump house (Plate - 1). A brief description of these 14 parameters of water quality is presented in the following paragraphs.

4.1 pH

The full form of pH is the potential of hydrogen which shows the alkaline and acidic condition of water (Shah and Joshi, 2017 and Kumar and Prakash, 2020). According to the Bureau of Indian Standard (BIS, 2012), the acceptable limit of pH value in drinking water is 6.5 - 8.5 and there is no relax for permissible limit. The average pH value of raw water of Kosi River is recorded 7.33 which varies between 7.13 in the month of September as the minimum and 7.47 in the month of March as the maximum. The pH value in Kosi river water is found under the acceptable limit of drinking water in all the months of the year (Table - 1).

4.2 Alkalinity (CaCO_3)

It is an important parameter of water quality. Alkalinity neither should be too much nor should be too less. It should be balanced (Raju et. al., 2014). According to the Bureau of Indian Standard (BIS, 2012), the acceptable limit of alkalinity in drinking water is 200 mg/l and the permissible limit is 600 mg/l in the absence of an alternative source. The average concentration of alkalinity is recorded 112.03 mg/l. The concentration of alkalinity varies between 54 mg/l in the month of February as the minimum and 159 mg/l in the month of November as the maximum. The concentration of alkalinity in the Kosi River water is found under the acceptable and permissible limit of drinking water in all the months (Table - 1).



Plate 1: The Kosi drinking water pump house at Kosi which is the site for the collection of water samples

4.3 Arsenic

The presence of arsenic in drinking water is considered a toxic and hazardous element to human health and high concentration may cause several diseases such as cardiovascular, neurological, hematological etc (Sankhla et. al., 2018). According to the Bureau of Indian Standard (BIS, 2012), the acceptable limit of arsenic in drinking water is 0 mg/l and the permissible limit is 0.05 mg/l in the absence of an alternative source. The toxic content of arsenic in the

Kosi river water is not reported in any month. All the samples are found within the range of acceptable and permissible limit of drinking water (Table - 1).

4.4 Calcium (Ca)

Calcium is an important element of drinking water. According to the Bureau of Indian Standard (BIS, 2012), the acceptable and permissible limit of calcium in

Table 1: Average month wise water quality status of raw water of Kosi River at Kosi drinking water pump house (2018 - 2020) (Source: Jal Sansthan, Almora).

S. N.	Parameters Months	pH	Alkalinity	Arsenic	Calcium	Fluoride	Chloride	Total Hardness	Iron	Magnesium	Nitrate	Sulphate	Turbidity	E. coli	Total Coliform	
			mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	NTU	MPN	MPN
			Acceptable limit	6.5 - 8.5	200	0	75	1	250	200	0.3	30	45	200	1	Absent
Permissible limit	No relax	600	0.1	200	1.5	1000	600	No relax	100	No relax	400	5	Absent	Absent		
1	January	7.37	133.33	0.0	38.87	0.51	8.30	155.67	0.01	14.10	4.80	10.00	1.09	17.87	368.10	
2	February	7.30	54.00	0.0	14.67	0.63	12.37	64.67	0.01	8.03	6.40	11.00	1.13	32.40	428.27	
3	March	7.47	111.00	0.0	41.33	0.33	6.83	116.67	0.00	17.30	2.90	8.67	1.31	28.43	418.00	
4	April	7.40	133.00	0.0	15.80	0.32	5.30	98.00	0.00	21.07	2.00	9.00	1.02	46.53	561.27	
5	May	7.30	71.33	0.0	20.87	0.43	6.27	117.67	0.01	11.27	6.10	11.33	1.08	36.03	633.77	
6	June	7.37	103.67	0.0	35.87	0.14	5.90	127.00	0.01	12.00	4.87	8.67	1.03	19.07	401.47	
7	July	7.33	78.00	0.0	24.60	0.11	7.33	102.00	0.02	10.50	6.10	7.33	0.96	26.53	453.50	
8	August	7.37	152.67	0.0	40.57	0.21	3.77	180.33	0.01	19.43	5.13	10.33	1.40	21.80	488.73	
9	September	7.13	98.00	0.0	30.37	0.66	3.80	128.00	0.01	13.30	1.97	7.00	1.40	41.83	402.23	
10	October	7.20	133.67	0.0	49.00	0.12	4.33	184.33	0.04	15.13	5.27	9.33	1.41	38.17	297.90	
11	November	7.40	159.00	0.0	40.60	0.50	4.60	181.33	0.00	19.43	4.47	8.67	1.42	39.33	405.93	

drinking water is 75 mg/l and 200 mg/l, respectively. The average concentration of calcium is recorded 33.30 mg/l. The concentration of calcium varies between 14.67 mg/l in the month of February as the minimum and 49 mg/l in the month of October as the maximum. The concentration of calcium in the Kosi River water is found under the acceptable and permissible limit of drinking water for all the months (Table - 1).

concentration of chloride in the river water is recorded 6.15 mg/l which varies between 3.77 mg/l in the month of August as the minimum and 12.37 mg/l in the month of February as the maximum. The concentration of chloride in Kosi river water is found within the range of acceptable and permissible limit of drinking water in all the months (Table - 1).

4.5 Fluoride

According to the Bureau of India Standard (BIS, 2012), the acceptable limit of fluoride in drinking water is 1.0 mg/l and the permissible limit is 1.5 mg/l in the absence of an alternative source. The concentration of fluoride in water varies from month to month. The average concentration of fluoride in the Kosi river water is recorded 0.36 mg/l which varies between 0.11 mg/l in the month of July as the minimum and 0.66 mg/l in the month of September as maximum. The concentration of fluoride in Kosi river water is found within the range of acceptable and permissible limit of drinking water in all the months (Table - 1).

4.7 Total Hardness

Rocks are the main source of hardness in water. Magnesium and calcium ions are frequently found in rocks and reach in water through runoff and percolation. Total hardness is the sum of calcium and magnesium (Bansal and Dwivedi, 2018 and Akram and Rehman, 2018). According to the Bureau of Indian Standard (BIS, 2012), the acceptable limit of total hardness in drinking water is 200 mg/l and the permissible limit is 600 mg/l in the absence of an alternative source. The average concentration of total hardness in the river water is recorded 134.19 mg/l which varies between 64.67 mg/l in the month of February as the minimum and 184.33 mg/l in the month of October as the maximum. The concentration of total hardness in Kosi river water is found within the range of acceptable and permissible limit of drinking water in all the months (Table - 1).

4.6 Chloride

Chloride is found in water naturally. According to the BIS (2012), the acceptable limit of chloride in drinking water is 250 mg/l and the permissible limit is 1000 mg/l in the absence of an alternative source. The concentration of chloride in water varies from month to month. The average

4.8 Iron

Iron is essential for good human health but its excessive amount and lack in the human body may cause dangerous

diseases. The high amount of iron content affects human health and results in haemochromatosis and Anemia disease caused due to the lack of iron (Raju, 2006). According to the Bureau of Indian Standard (BIS, 2012), the acceptable limit of iron in drinking water is 0.3 mg/l and there is no relax for permissible limit. The average concentration of iron in the river water is recorded 0.01 mg/l which varies between 0.0 mg/l as the minimum and 0.04 mg/l as the maximum. The concentration of iron in Kosi river water is found within the range of acceptable limit of drinking water in all the months (Table - 1).

4.9 Magnesium

Magnesium is found in water naturally from sedimentary rocks and it is important for all living things (Kumar and Prakash, 2020). According to the Bureau of Indian Standard (BIS, 2012), the acceptable limit of magnesium in drinking water is 30 mg/l and the permissible limit is 100 mg/l in the absence of an alternative source. The concentration of magnesium varies from month to month. The average concentration of magnesium in the Kosi River water is recorded 15.19 mg/l which varies between 8.03 mg/l in the month of February as the minimum and 21.07 mg/l in the month of April as the maximum. The concentration of magnesium in Kosi river water is found within the range of acceptable and permissible limit of drinking water (Table - 1).

4.10 Nitrate

The major anthropogenic source of nitrate in surface and groundwater is chemical fertilizer (Shah and Joshi, 2017). According to the Bureau of Indian Standard (BIS, 2012), the acceptable limit of nitrate in drinking water is 45 mg/l and there is no relax for permissible limit. The concentration of nitrate varies from month to month. The average concentration of nitrate in the river water is recorded 4.39 mg/l which varies between 1.97 mg/l in the month of September as the minimum and 6.40 mg/l in the month of February as the maximum. The concentration of nitrate in Kosi river water is found within the range of acceptable and permissible limit of drinking water in all the months (Table - 1).

4.11 Sulphate

Sulphate occurs in water with the natural process. The high concentration of sulphate in drinking water may cause of ill health (Appavu et. al., 2016). According to the Bureau of Indian Standard (BIS, 2012), the acceptable limit of sulphate in drinking water is 200 mg/l and the permissible limit is 400 mg/l in the absence of an alternative source. The concentration of sulphate varies from one month to another. The average concentration of sulphate in the river water is recorded 9.56 mg/l which varies between 7 mg/l in the month of September as the minimum and 13.33 mg/l in the month of December as the maximum. The concentration of sulphate in Kosi river water is found within the range of acceptable and permissible limit of drinking water in all the months (Table - 1).

4.12 Turbidity

Turbidity is an important parameter of drinking water quality used all over the world (Gauthier et al, 2003). Low concentration of turbidity in drinking water is considered safe and fit for human health as well as aquatic life (Pareek et. al., 2020). According to the Bureau of Indian Standard (BIS, 2012), the acceptable limit of turbidity in drinking water is 1 NTU (nephelometric turbidity unit) and the permissible limit is 5 NTU in the absence of an alternative source. The average concentration of turbidity in the Kosi river water is recorded 1.24 NTU which varies between 0.96 NTU in the month of July as the minimum and 1.63 NTU in the month of December as the maximum. The concentration of turbidity in Kosi river water is found out of the range of acceptable limit and within the range of permissible limit of drinking water in all the months (Table - 1).

4.13 E. coli

E. coli is a part of the faecal coliform group which is a significant indicator of faecal induced water pollution. All the living organisms, e. g., humans, livestock etc are the main source of faecal pollution. The consumption of faecal contaminated water becomes the cause of several waterborne diseases (Odonkor and Ampofo, 2013). As per the guideline of the Bureau of Indian Standard (BIS, 2012), the content of e. coli in drinking water should be absent. The average concentration of e. coli in the river water is recorded 34.30 MPN (most probable number) which varies between 17.87 MPN in the month of January as the minimum and 63.57 MPN in the month of December as the maximum. The concentration of e. coli in Kosi river water is found more from of the acceptable and permissible limit in all the months (Table - 1).

4.14 Total Coliform (TC)

The guideline of the Bureau of Indian Standard (BIS, 2012) specifies the level of total coliform in drinking water as absent. Total coliform is a group of several bacterial species origin from human and animal faecal and other sources (Antony and Renuga, 2012). The average concentration of total coliform in the Kosi river water is recorded 442.46 MPN (most probable number) which varies between 297.90 MPN in the month of October as the minimum and 633.77 MPN in the month of July as the maximum. The concentration of total coliform in Kosi river water is found more from of the acceptable and permissible limit in all the months (Table - 1).

5. Conclusion

The present study reveals that due to indiscriminate human activities in the catchment area of the Upper Kosi River, the quality of Kosi river water is declining steadily. The study concludes that out of the total 14 parameters, 11 parameters (i. e., pH, alkalinity, arsenic, calcium, fluoride, chloride, total hardness, iron, magnesium, nitrate and sulphate) are found within the acceptable and permissible limit while 03 parameters (i. e., turbidity, e. coli and total coliform) are found exceeding the acceptable limit. Based on this study it can be stated that all the physicochemical parameters of

Kosi River water are within the prescribed acceptable limit but the bacteriological parameters are exceeding the prescribed limit of drinking water. Thus, it is suggested that human activities along with the river site and untreated disposal of sewerage into the river should be strictly banned to get safe drinking water.

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