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Study on Water Quality Index & Status of Three Rivers (Khan, Narmada and Kshipra)

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***Abstract*:** The present study intended to calculate the Water Quality Index (WQI) of Narmada, Khan and Kshipra River at ten sampling points flowing through the districts of Indore, Khargone and Ujjain, Madhya Pradesh. All the three tributaries having religious significance and Narmada is one of the lifeline of M.P. Due to anthropogenic activities these rivers are highly polluted. The present study is based on seasonal monitoring of physico chemical parameters and observed the status of WQI of these tributaries seasonally and also compared the WQI with the previous data. The physico-chemical parameters were measured during the study period. The results obtained from the application of ICMR WQI concluded that, the overall water quality index of year 2014-15 was calculated as 84.46 which fell under the Very Poor water quality class (index value between 76-100). The water quality index reduced towards the year 2018-19 of the river it is 59.42 which shows the poor water quality class (index value between 51-75). The level of water pollution is slightly improved as compared to previous years.

***Keywords*:** Water Quality Index, Tributaries, Khan River, Physico-Chemical Parameter.

I. INTRODUCTION

River water pollution is challenging issue in India due to continuous urbanization and rapid industrialization for sustainable development [1]. Most of the industries are disposing off their waste directly to the nearby stream without making any treatment and violating the provisions for standard laid out for the same [2].On national and state levels several policies and regulations like Water Act, 1974 (Prevention and Control of Pollution) to regulate pollution discharges and restore water quality of aquatic resources including the prescription of monitoring activities. Now a day's water quality assessment as major concern as it is getting deteriorated by human activities [3].

The river Khan is the main river of Indore city to fulfill the demand of water required in the various sector. The main sources of pollution of Khan River water is industries (small scale and large scale) are situated nearby the River bank area. Usually these are generated harmful waste containing so many types of toxic and harmful substances [2]. Also the river Khan is the biggest source of contamination to river Kshipra carrying high organic content, chemicals and heavy metals. Another major source of contamination is the domestic wastewater generated from Ujjain city [4].

Many researchers have studied and established various methods to assess water quality, including WQI in these river &tributaries. [2] An experimental work on water quality of River Khan for post monsoon and winter season for a period of seven month (NOV 2013 to May 2014) and CCME WQI conclude that Khan River has all the parameter(namely pH,EC,TDS,Na+,K+,Cl-,SO4 ,SAR, %Na and Boron) of class E standard. [5] Physicochemical Monitoring of river Khan at Triveni, Ujjain. In these studied analytical data were obtained for BOD, COD, turbidity and TDS values were very high due to the several industries in Indore, which discharge their effluents in the river and it also receives untreated sewage, drainage, run off from the villages. Results were indicating that the water body was not fit for use. [6] The quality of water at Khan River because of the uncontrolled flow of municipal and domestic sewers dumping directly into river, various variables were found in the river khan. [7] To assessed the impact of mass bathing on water quality of River kshipra during Kumbhmela at Ujjain from 22 April 2016 to 21 may 2016. The physico-chemical parameters were analyzed in all the Ghats are polluted but Mangalnath ghat is highly polluted because maximum people were visited in this ghat while than Narsingh ghat and Lalpul ghat was less polluted. It was also observed that all parameters were present in low levels at the Triveni ghat, which was the least used for bathing by pilgrims and remain least disturbed zone among the sampling ghat. As per Central pollution control

board (CPCB) norms water was found to be of D class and was not fit for drinking and bathing purpose. [8] The surface water pollution of Khan River. Indore city has deteriorated to a large extent making it unfit for drinking and irrigation purpose. The chemical composition of groundwater from basaltic aquifer has severely altered due to the surface water pollution. [9] The study based on critical analysis and testing of various European methods under the Indian conditions in the River Khan. A total 14 water quality parameters were studied on minimum and maximum values like color, pH, total dissolved solids, Phosphate, total alkalinity, chloride, total Calcium Hardness, nitrate, biochemical oxygen demand, chemical oxygen demand, Sulphate, Sodium and potassium were observed. [10] WQI based on pH, EC,TDS, turbidity, DO, BOD, COD, TA, TH, Ca, H, Mg H, Na+, K+, Cl-, F-, NO-3, SO2- 4, PO4- and boron parameters as per I.S. 3025.

The objective of this study was to monitor water quality trends and status of WQI of three tributaries. The study was carried out at riverine regions of river Narmada, one of the four major rivers of Gujarat. The researchers revealed that some parameters like Total Hardness, Turbidity, and Total Dissolved Solids values were found to be out of acceptable range of IS 10500 – 2004 from the view point of domestic purpose; because sources of pollution that the river receives mainly by means of industrial effluent, agricultural runoff, and domestic sewage [11]

The water quality of river can predict by using the Water Quality Index. Basically a WQI attempts to provide a mechanism for presenting a cumulatively derived, numerical expression defining a certain level of water quality [12].It is introduced as a mathematical instrument to convert the water quality dataset into a single number which represents the water quality and biases of individual water quality experts [13].

II.RELATED WORK

Preliminary Integrated Study on Water Quality Index of Three Tributaries (Khan, Narmada and Kshipra River): Indore had been determined [14].This study assessed the WQI of these tributaries seasonally. The physico-chemical parameters were measured. The main objective of study was to surveillance the WQI at different tributaries for two seasons post monsoon and winters seasons. The WQI value in most of the stations were observed to be more than 100 in both the season indicated the water quality was poor and totally unsafe for human consumption [14].
All three tributaries was subjected to varying degree of pollution due to addition of untreated and/or partially treated waste inputs of municipal and industrial effluents as assessed by water quality index. [14].

III. MATERIALS AND METHODS

Study Area: The criteria of study area is based on the intermixing of the rivers and tributaries at Indore ,Ujjain and Omkarheswar.The salient features of river and their tributaries are given in table-2.

Sampling Station: Selection of sampling station based on the availability of sources and industrial effluent, sewage load dumping in to the rivers. Ten samples were collected from three sites, the schematic diagram of three tributaries is given in fig-1.shows the selected sampling stations and their description is given in table -2.

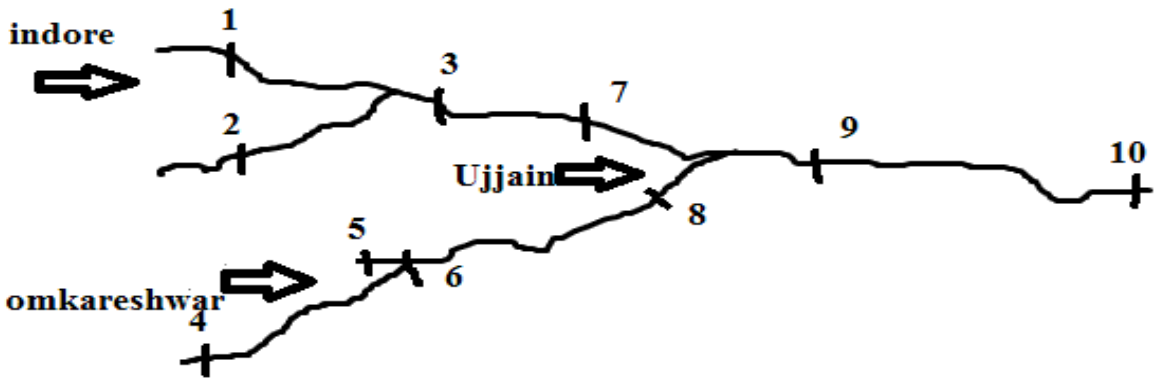

Fig-1. Outline Sketch Diagram of Selected Sampling Stations (1-10)

Figure: 2: View of Khan River in Indore city at Krishanpura Bridge

Figure: 3: View of Khan River in Sanwer Gaun at Trivedi Ghat

Selection & Analysis of physico-chemical parameters:
Selection of parameters as per the water quality monitoring program and All the parameters like pH, turbidity, TDS, TSS, hardness, chloride, DO, COD, BOD, total alkalinity, carbonates, bicarbonates were determined as per standard methods APHA (20^{th} edition ,1998).

Water Quality Index:
Numerous researchers have been used WQI in interpretations of water quality in the literature. In 1965, Horton made a pioneering attempt to study the general indices, selecting and weighting parameters. To find out water quality with respect to organic & bacterial pollution, National Sanitation Foundation (NSF) created and design a standard index called the Water Quality Index (WQI), using the Delphi technique as a tool in a formal assessment procedure [15]. A water quality index (WQI) simply indicates a large amount of water quality data put into simple terms viz. poor, fair, good, or excellent for reporting to the public, government or project authorities in a simplified and lucid manner. A water quality index expressed as a single number is developed to describe overall water quality conditions using multiple water quality variables For each tests (BOD,COD ,DO, pH, TSS, TDS, Hardness Turbidity ,Temperature and fecal Coliform etc), the numerical value or Q value is multiplied by ―Weighting factor [5]. Most water quality indices rely on normalizing or standardizing data parameter by parameter according to expected concentrations and some interpretation. The WQI is the one of the most widely used of all existing water quality procedures [4].Therefore, WQI is simplified way of representing water quality information.

The WQI has been calculated by using the standards of drinking water quality recommended by the World Health Organization (WHO), Indian Council of Medical Research (ICMR, 1975) and Bureau of Indian Standards (BIS) has been used for the calculation of WQI of the water body. [16] [17].

Further, quality rating or sub index (*qn*) was calculated using the following expression.

Qn = 100 (Vn – Vio) / (Sn – Vio)

Where:

Qn=Quality rating for the nth Water quality parameter.

Vn=Estimated value of the nth parameter at a given sampling station.

Sn =Standard permissible value of the nth parameter.

Vio = Ideal value of nth parameter in pure water, (i.e.0 for all other parameters except the parameter pH and Dissolved oxygen (7.0 and 14.6 mg/L respectively).

Unit weight was calculated by a value inversely proportional to the recommended standard value Sn of the corresponding parameter.

Wn =K / Sn

Where:

Wn= Unit weight for the nth parameters.

Sn= Standard value for nth parameters.

K= Constant for proportionality.

The overall Water Quality Index calculated by aggregating the quality rating with the unit weight linearly.

WQI =ΣqnWn / ΣWn

Table-3.1 & 3.2: Status and Index level (WQI) of water quality Drinking water standard recommending agency (ICMR) and unit weight (All value except pH and Turbidity (NTU) is in mg/l)

IV. RESULTS AND DISCUSSIONS

The wastewater samples from Khan river at Kabitkhedi before STP, Khan river at Kabitkhedi after STP, Shakarkhedi, Narmada River Omkareshware , Kshipra river Ujjaini, Narmada–Kshipra river, Jamal pura, Triveni Ghat ,Dhediya ,PrashantDham, Ram Ghat were collected in 2018 and analyzed for physicochemical parameters. Data of physico-chemical and Calculation of WQI based on ICMR Standard Value, Unit Weight and Quality Rating all these values are similar or constant, which are given in table 3:

The graphical representation of all parameters at ten sampling stations from a to h.

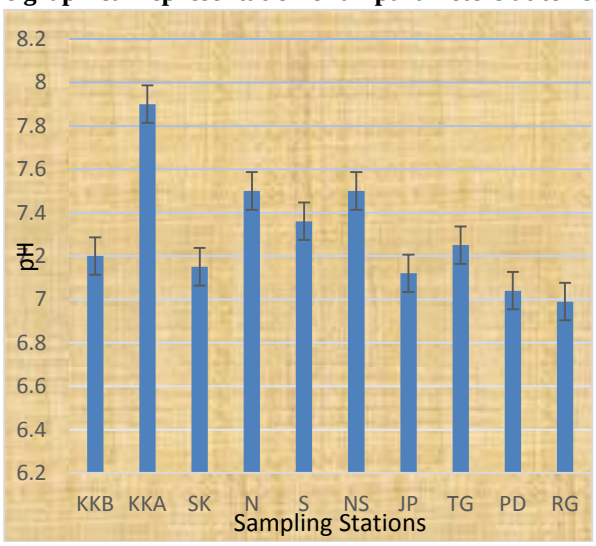

Fig- 4-Variation in pH value of S1 to S10 stations

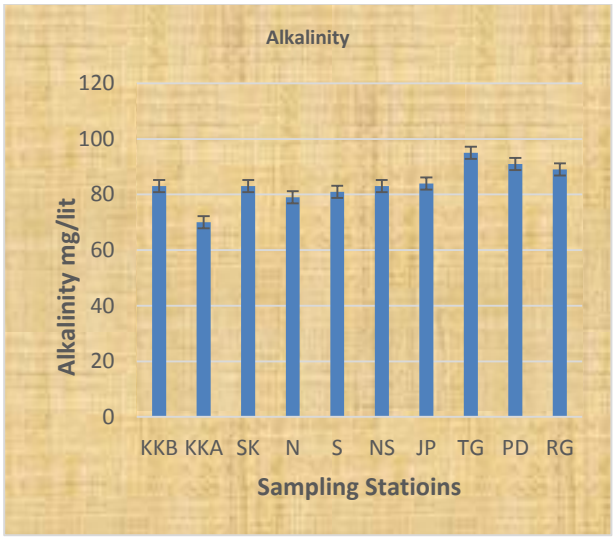

Fig-5-Variation in Alkalinity value of S1 to S10 stations

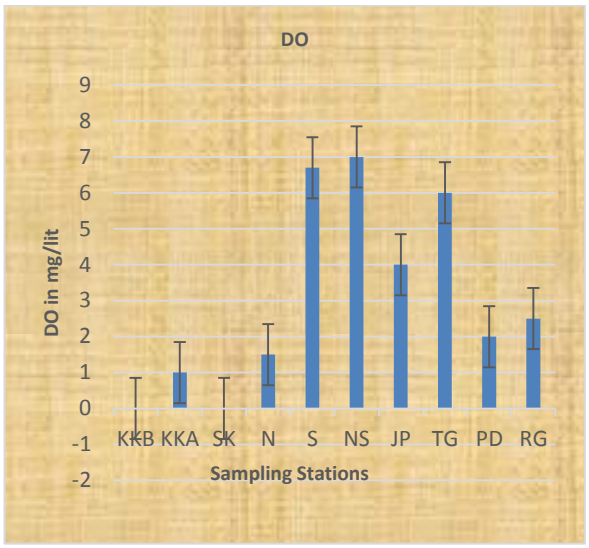

Fig-6-Variation in DO value of S1 to S10 stations

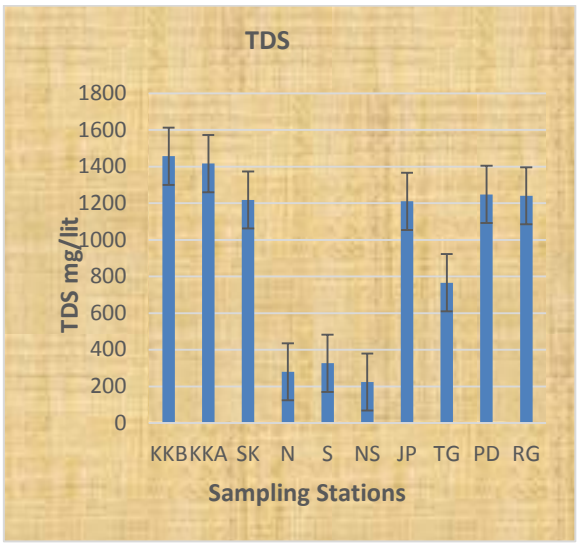

Fig-7-Variation in TDS value of S1 to S10 stations

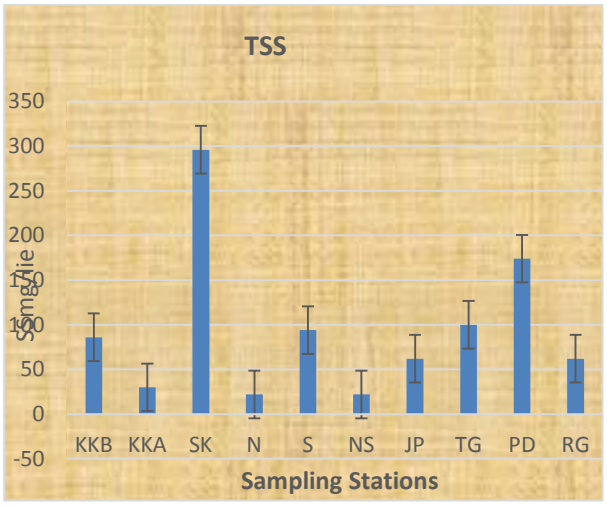

Fig-8-Variation in TSS value of S1 to S10 stations

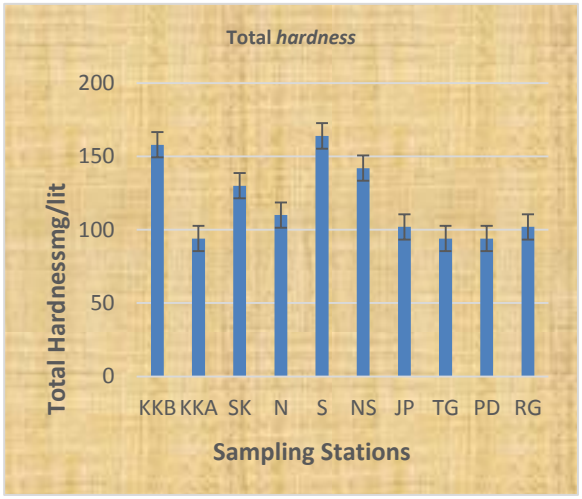

Fig-9-Variation in Total Hardness value of S1 to S10 stations

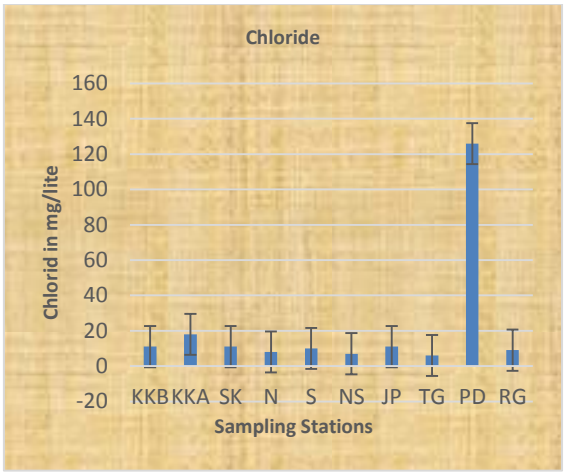

Fig-10-Variation in Chloride value of S1 to S10 stations

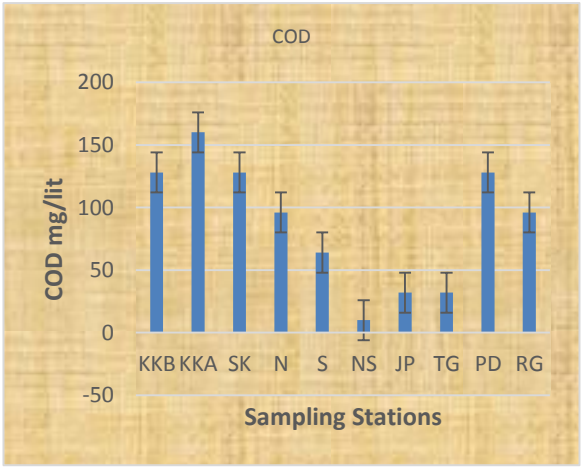

Fig-11-Variation in COD value of S1 to S10 station

Status of Three Tributaries: In present study DO, Cl- , COD and TDS these parameters showed a high variation for all stations.

A large variation found for TDS these values comparatively were low at station S4, S5 and S6 these values showed the land filling pattern followed in this area and greenery and soil erosion is less but its value was high at S1, S2, S3 and S9 While it was very high at S7, S8, S10.These very high value indicate the sewage discharge and anthropogenic activities along the river bank areas at these stations. DO was a principle pollution indicator. For S1, the DO was 1.5mg/lit comparatively less value that means high organic load at this station due to the discharge of domestic waste and other waste in this water. At the stations S2 to S10 DO level was found sufficient amount for the surviving of aquatic life in range between 5 to 6.4 mg/lit.
Similarly a variation found for COD its range from 64 to 224 mg/lit was found in S1 to S10 stations which were higher than standard limit. Higher COD values indicate the Chemical reaction was occurred continuously in water due to biodegradation load.

This assessment study indicated an informative data which was showing the contamination of waste water in tributaries. The major source of pollutants was sewage waste water and human house hold work, dumping of small scale industries effluent and agricultural runoff. The present study reveals that physico- chemical parameters of some sampling stations crossed the ICMR maximum permissible limit.

In both the years 2014- 15[14] and 2018- 19 the value of COD were 3 to 5 times higher in each sampling station and DO was higher only at S1 station while TDS was higher in maximum sampling stations and TSS was higher only S1 station. The value of DO was far less than standard value only S1 station but higher for some station which affects the aquatic flora and fauna adversely. The value of turbidity was also zero and the value of pH, Total hardness and total alkalinity were under the permissible limit (table-2). The study clearly indicate the COD is higher in monsoon season that is pollution of organic and inorganic contaminates is higher. Value of parameters indicates balance of river water was disturbed. During the post-monsoon period, there are slight changes in the water quality of the river water due to dilution.

Status of Water Quality Index of Three Tubituries:
The water quality index of three water bodies was calculated using various physico -chemical parameters in both the years.

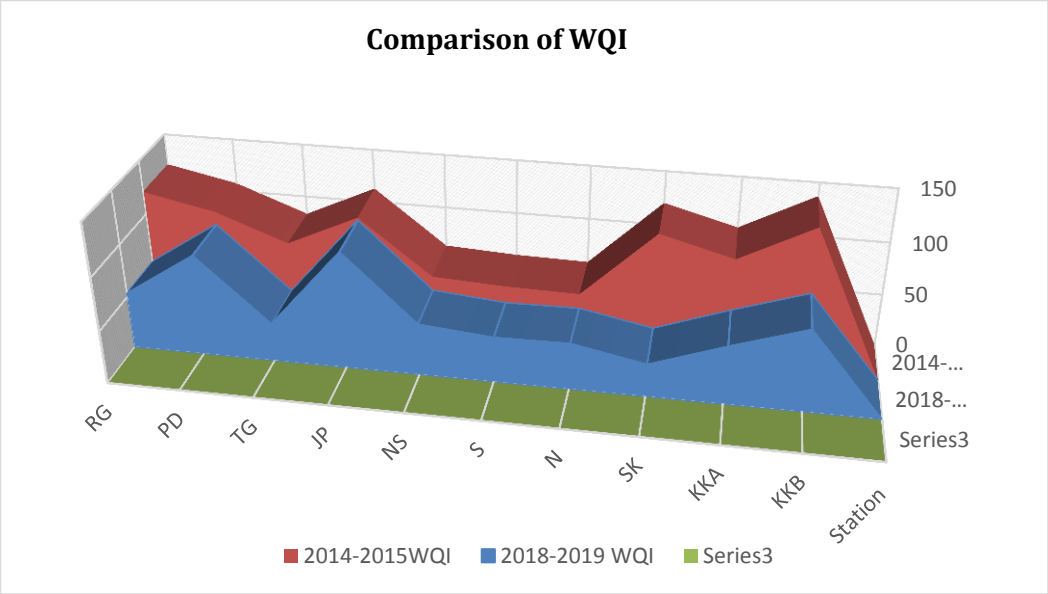

Fig- 13- Comparison of WQI of 2018-19 with 2014-15

The overall water quality index of year 2014-15 was calculated as 84.46 which fell under the Very Poor water quality class (index value between 76-100). The water quality index reduced towards the year 2018-19 of the river it is 59.42 which shows the poor water quality class (index value between 51-75). In year 2014-15 Site S1 has the highest index value compared to other sampling sites. While in the year 2018-19 site S7 has the highest index value compared to other sampling sites.S4 showed the least quality index range (57.25) in the year 2014-15 whereas Site S3 is found to be in the lower index range (30) 2018-19. Since the overall value of water quality index has been decreases (range from 84.46 to 59.42) shows the quality of water is

improved in between the period of 4 years from 2014 to 2018. And overall % of water quality is improved at the some stations due to awareness of peoples to environment and active action of governments and different organization of pollution control board and environment. Decreasing in value of WQI is also shows the development of STP.

But the mean value of WQI is 71.94 which show the very poor water quality according to ICMR Standard limit. The study concluded that due to discharge of untreated sewage into the rivers, the water quality has been continuously detoriate and the quality of drinking water is being lost. The overall analysis of the both the years makes it amply clear that the water of the year 2018-19 is comparatively better than that of water of the year 2014-15.

While WQI value of 2018-19 is better than WQI of 2014-15 this means that quality of surface water is improved and pollution level has been controlled and disposing of effluents in to river water also has been controlled.

Because of Swatch Bharat Mission Program run by Indian Government from last 2014 in India. In recent year in Khan River rejunavation process is going on based on the STP development process for separating the sewage water (nalla) in to river.
WQI value of 2018-19 of S1, S2, S3 and S10 stations are 4 times less than previous value this data shows the water quality and pollution level is an improving stage due to the awareness of people and controlled pollution level.

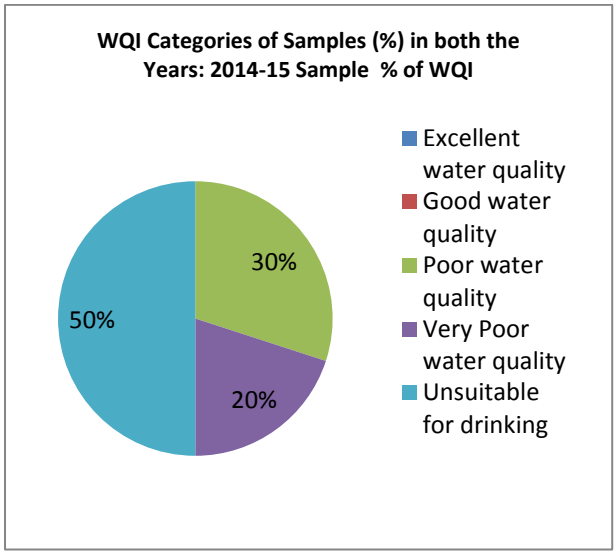

Fig-14: WQI Categories of sample% in 2014-15

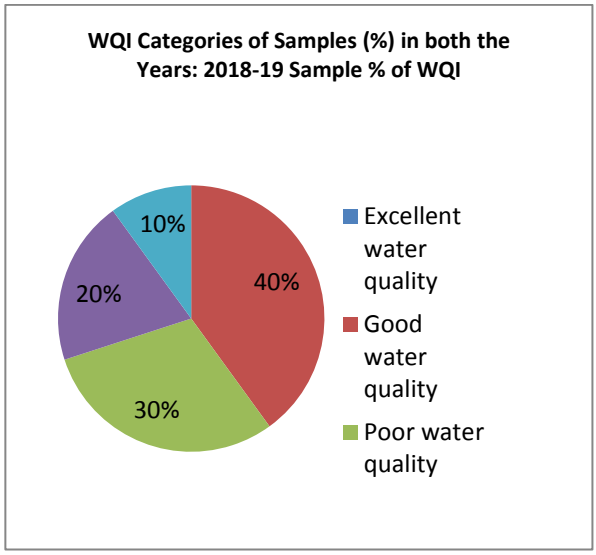

Fig-15: WQI Categories of sample% in 2018-19

V. Conclusion: In this research study, all the physico-chemical parameters showed variation at the all sampling stations along the three tributaries. Study concluded that the overall WQI of 2014-15 is higher than WQI of 2018-19.And the mean value of WQI of 2014-15 to 2018-19 is71.94. Comparatively 2018-19 WQI value is better but not good or satisfactory (table-2).

Lastly overall % of water quality is improved at the some stations. 40 % sample stations of 2018-19 belongs to good water quality class of ICMR (table -2) which was 0% in 2014-15.Similarly only 10% sample stations belonged unsuitable for drinking class of ICMR (table-2) which was 50% in 2014-15 (Fig-2).

Overall results showed a continuously improvement in water quality only at some sites due to the solid waste management practices, 100 % door to door collection of waste at commercial and domestic level by IMC Indore. In recent year in khan river water rejuvenation process is going on, STP development process for separating the sewage water (nalla) in to river. But still continuously directly discharge of sewage waste and industrial effluent in to the source at some sites due to the lack of proper sanitation, misuse of river bank areas, and urban runoff. For improving this regular water quality monitoring is must and identifies all those things which are responsible for this surface water pollution in all three tributaries and also minimize the discharge of sewage water or untreated water in to the source.

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Authors Profile

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Prof. Rubina Chaudhary had pursued M.Sc. Analytical Chemistry, M.Phil and Ph.D in Environment from Aligarh Muslim University, Aligarh U.P. in 1986, 1989, and 1993. Currently working as professor in School of Energy and Environmental Studies, Devi Ahilya University, Indore, M.P. since 1999. She is member of SEAC since 2018.She has published more than 60 research papers in reputed international journals.

Table -1 –Salient Features of three Rivers:

Sl.No.	River	Major Tributaries	Length(From origin) Km	Longitudes & Latitudes	Description	Reference
1.	Khan	The Saraswati River	72	22°37_ N and 75°54_ E	• Life Line of Indore City • Origin Point is Limbodi • 21 KM flow through Indore city	[2]

2.	Narmada	The Shakkar ,The Sher ,The Tawa,TheDudhi ,The Ganjal The Choral ,TheLohar ,The Karam ,The Hiran ,The Barna	>1,000	72°32′ E to 81°45′ E &21°20′ N to 23°45′ N	• Life Line of M.P. • Amarkantak is the origin place of the Narmada in MP. • The basin covers 86% of MP,14% of GJ and 2% of MH average population density in the Narmada basin is significantly lower than the Indian national population average of 324 person km−2	[13]
3.	Kshipra	The Khan	195	" 23°18′ N to 75°77′ E	• Origin place is Kakari-Badi hill 11 km from ,Indore • Life line of Ujjain City • 93 KM flow through Ujjain city	[14]

Table 2: Description of Sampling Station code

Zone	Sampling Station Code	Description
Zone-1	S-1	Khan river at Kabitkhedi, before STP
	S-2	Khan river at Kabitkhedi ,after STP
	S-3	Shakarkhedi
Zone-2	S-4	Narmada River ,Omkareshware
	S-5	Kshipra River ,Ujjaini
	S-6	Narmada –Kshipra river,
	S-7	Jamal pura
	S-8	Triveni Ghat ,Dhediya
	S-9	PrashantDham
	S-10	Ram Ghat

Table-3.1 & 3.2: Status and Index level (WQI) of water quality Drinking water standard recommending agency (ICMR) and unit weight (All value except pH and Turbidity (NTU) is in mg/l)

Table 3.1

Physico-Chemical Parameter	Standards (Sn)	Unit Weight
pH	6.5-8.5	0.2403
Total Hardness mg/lit	300	0.0062
DO mg/lit	5	0.3720
BOD mg/lit	5	0.3720
Chloride mg/lit	250	0.0074
TDS mg/lit	500	0.0037
Alkalinity mg/lit	120	0.0155
COD mg/lit	25	0.0744
TSS mg/lit	500	0.0037
Turbidity	5	0.3720

(Source: ICMR-1975)

Table 3.2:

Water Quality Index Level	Water Quality Status
0 – 25	Excellent water quality
26 – 50	Good water quality
51 – 75	Poor water quality
76 – 100	Very Poor water quality
>100	Unsuitable for drinking

(Source: ICMR-1975)

Table 4: Observed value of Sampling Station & Calculation Wnqn

parameter	Observed value of Sampling Station									
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
pH	7.2	7.9	7.15	7.5	7.36	7.5	7.12	7.25	7.04	6.99
Alkalinity(mig/lit)	83	85	83	79	81	83	84	95	91	89
DO (mig/lit)	0	1	0	1.5	6.7	7	4	6	2	2.5
TDS(mig/lit)	1456	1416	1218	280	394	326	326	766	1248	1240
TSS(mig/lit)	86	30	296	0.0163	94	22	62	100	174	62
Total Hardness(mig/lit)	158	94	130	110	164	142	102	94	94	102
Chloride(mig/lit)	11	17.99	12	16.87	11	7	11	6	125.96	9
COD(mig/lit)	224	160	128	28.5696	64	10	32	32	128	96

Continue:

sn	wn	qn	Wnqn									
			S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
7.74	0.2431	27.02	10	24.5277	4.8686	23.2858	11.6886	16.2353	3.8954	8.1176	1.2976	0.3244
120	0.0155	69.1666	1.0720	224	1.0720	1.0204	1.0462	1.0720	5.1661	1.2270	1.1754	1.1495
5	0.372	0	0	7.44	0	11.16	30.6230	29.42892	41.04648	33.30144	48.7915	46.8571
500	0.0037	400	1.488	1.0535	0.9061	0.2083	0.2931	0.2425	0.9002	0.5699	0.9285	0.9225
500	0.0037	120	0.4464	0.0223	0.2202	0.0163	0.0699	0.01636	0.0461	0.0744	0.1294	0.0461
300	0.0062	90	0.558	0.1942	0.2686	0.2273	0.3389	0.2934	0.5952	0.1942	0.1942	0.2108
250	0.0074	4.4	0.0327	0.0535	0.0357	0.0502	0.0327	0.0208	0.0327	0.0178	0.3748	0.02678
25	0.0744	896	100	47.616	38.0928	28.5696	19.0464	2.976	9.5232	9.5232	38.0928	28.5696

Table -5- Overall WQI (2014-15 & 2018-19):

Year	**Overall WQI**	**Water category (ICMR)**
2014-15	96.55	Very Poor water quality
2018-19	59.46	Poor water quality

