Research article Available online www.ijsrr.org ISSN: 2279–0543

International Journal of Scientific Research and Reviews

Monitoring and Assessment of Surface Water Quality with Seasonal Variations at Different Stretches from Upstream To Downstream of Yamuna River, Faridabad, Haryana, India

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ABSTRACT

The Yamuna River's surface water fulfills the diverse needs and is the primary water resource for various domestic, irrigation and other purposes for the survival of the inhabitants of the Faridabad city. But today over increasing demography, rapid developmental activities, industrialization and urbanization are the major key factors largely contributed to worsening and deterioration of the Yamuna River's water quality. In this context, the present work was intended on seasonal basis from May 2016 to April 2017 to examine the Yamuna River's water quality at different stretches in Faridabad city of Haryana State, India. In order to determine the excellence of river water, eleven different sampling sites of river Yamuna from upstream (Entry point in Faridabad) to downstream (exit point of Faridabad) of Faridabad district were taken to assess the various selected physico-chemical (Temperature, pH, EC, SS, TDS, TS, TH, CaH, MgH, Ca, Mg, Chloride and DO) parameters. Methods prescribed by APHA (American Public Health Association), were used during the research work. From the observations and results of the study, it was revealed that the Yamuna River's water quality has been heavily deteriorated at drain sites. Therefore, this river needs the qualitative aspects of supervision for predicting the flowing water quality conditions.

KEY WORDS: Faridabad, River Yamuna, River pollution, Water quality and Physico-chemical parameter.

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INTRODUCTION

Water is a most important natural resource, an essential for all creature's necessity and a valuable national asset, hence its usage demands appropriate planning, proper management and progressive development[1]. Unfortunately most of the surface water-bodies are beneath severe ecological stress and are being susceptible due fast industrial and urban developmental actions, which added huge loads off pollutants to our water bodies[2]. The River Yamuna is a sacred river yet most polluted river of the India. Its origin point is Yamunotri glacier at Saptrishi kund near Banderpoonch peaks in Himalayas and covers 1376 km distances from its origin over the Delhi (touches Delhi–NCR also), Haryana and Uttar Pradesh, then meet with the Ganga River at Allahabad, Uttar Pradesh[3,4,5]. From the last few decades, the Yamuna river, has become progressively more polluted and rather pathetic from both pollution sources i.e. point pollution sources which includes domestic sewage, human and cattle inputs and industrial effluents whereas agricultural runoff and erosion comes under non-point pollution sources[4]. As per the survey of CPCB (Central Pollution Control Board), the Yamuna river accounts for supply of river water about more than 70% to the Delhi city and about 57 million inhabitants depend on river water for their usage on daily basis[6] and approximately 350 industrial clusters that throw their wastes in Yamuna in Delhi only, which then flows towards Faridabad city of Haryana state[7,8]. The river Yamuna receives domestic sewage and industrial waste-water from massive industrial units at Faridabad which is 9th biggest industrial city of Asia[3] has numerous of varied small, medium and large scale industries which dealing in production of lubricants, rubber paints glues, pigments dyes, pharmaceuticals, ceramics, metallurgy, electrical appliances, electroplating, machine tools, and batteries. Even after the directions and strict instructions of pollution control board to set up ETPs and discharge industrial effluents only after treatment, but they still continuously releasing effluents without prior treatment either in to the river or dispose off on to the ground[6]. To investigate the Yamuna River's water quality various physico-chemical parameters have been assessed from last several years at different places by numerous researchers but till date Yamuna is still most contaminated water body in India, mainly at Delhi region. Therefore, this present investigation has been done to examine the selected various physico-chemical parameter of surface water at different stretches of river Yamuna at Faridabad district of Haryana for one year across five different seasons viz. summer, monsoon, post-monsoon, winter and spring to detect the pollution levels of this water body so that best possible remedial strategies can be acquired to restore and manage the water quality and biodiversity of Yamuna River.

MATERIALS AND METHODS

Study Area:

In India, Faridabad city is the well known district of Haryana State which located on south eastern part lies between 270˚ 39', 280˚ 31' north latitude and 760˚ 40' and 770˚ 32' east longitudes. The Delhi (Union territory) bordered Faridabad from north direction, Mewat district of Haryana in north-west direction, in the east direction bordered from UP state, Gurgaon district of Haryana by west direction and Palwal districts of Haryana bordered it in the south direction (figure 1).

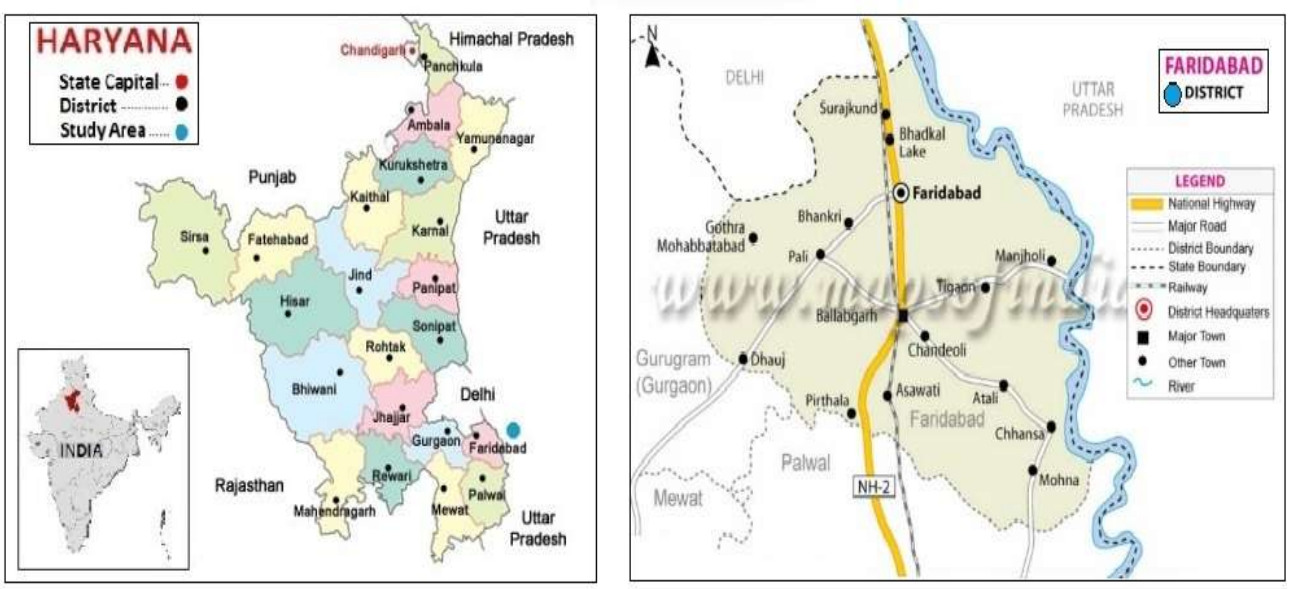

Figure 1: Location of Study area (Faridabad)

Faridabad and Ballabhgarh divides the Faridabad district into Two Blocks. Total geographical vicinity of the Faridabad is 2151 square kilometer which is primarily shattered by the Yamuna River, a perennial river flows in very close proximity to the city at its north direction and moves away towards south direction. The Aravalli hills bounded the Faridabad by west direction. Faridabad has semi-arid climate with very little and irregular rainfall. During summer season, temperature may reach upto 45˚ C in June month while in winter season it drops to 1.9˚ C in February month. May and June are the hottest and driest months, when dust storms from the west direction overcome with high speed.

Methodology

For the purpose of the seasonal assessment of Yamuna River's water quality, total eleven sampling sites (figure 2) were selected which covering the approx. 40 km stretch of Yamuna River in district Faridabad of Haryana state.

Figure 2: Location of sampling sites

GPS location details of all the sampling sites are demonstrated in table 1. Surface water samples of River Yamuna were grabbed from May 2016 to April 2017. The complete study duration were categorized into five different seasons i.e. Summer season (May and June), Monsoon season (July, August, September), Post-monsoon season (October and November), Winter season (December, January and February) and Spring season (March and April).

The collected river's surface water samples were tested for thirteen various physico-chemical parameters as per the standard methods analysis protocols APHA[9]. Samples of river's water were grabbed in sterilized sampling polyethylene bottles of one liters capacity which were rinsed three times with samples, collected samples were preserved and instantaneously transported to laboratory and store at 4° C until their various physico-chemical parameters were analyzed. The parameters analyzed were pH, Temperature in degree Celsius, Total dissolved solids (TDS) in mg/l, Electrical conductivity (EC) in µS/cm, Suspended solids (SS) in mg/l, Total solids (TS) in mg/l, Total Hardness (TH) in mg/l, Calcium Hardness (CaH) in mg/l, Calcium (Ca^{2+}) in mg/l, Magnesium hardness (MgH) in mg/l, Magnesium (Mg^{2+}) in mg/l, Chloride (Cl^{-}) in mg/l and Dissolved oxygen (DO) in mg/l. The temperature and DO were detected at the collection site.

Table 1: GPS Location of all the sampling sites

Site Code	Site Name	Type of Site	Latitude (N)	Longitude (E)	Altitude (m)	Location
S1.	Faridabad Upstream	Upstream	28˚ 30' 54.73"	77˚20'26.80"	136	Entry point in Faridabad and ½ km up from the site S2.
S2.	Basantpur Drain	Industrial	28˚ 30' 38.41"	77˚20'47.61"	141	Approx. 10 km down from Okhla barrage, New Delhi.
S3.	No Drain-1	No Drain	28˚ 29' 51.48"	77˚21'7.45"	149	1 km down from the Site S2.
S4.	No Drain-2	No Drain	28˚ 23' 25.14"	77˚29'35.72"	136	1 km up from the site S5
S5.	Budhia Nala	Industrial	28˚ 22' 59.96"	77˚29'11.66"	133	11 km down from Basantpur Drain site and 7 km approx. up from the site S6
S6.	Chandpur Drain	Domestic	28˚ 19' 30.81"	77˚27'59.51"	133	7 km approx. down from the Budhiya Nala site
S7.	Imamuddinpur Drain	Domestic	28˚ 19' 23.22"	77˚27'56.11"	132	400-450 m approx. down from the Site S6 and 6 km approx up from the site S8
S8.	Arua Drain	Domestic	28˚ 18' 21.95"	77˚27'49.96"	133	8 km approx. up from the site S9
S9.	Chhainsa Drain	Domestic	28˚ 15' 23.90"	77˚28'4.32"	132	6.5 km approx. up from Mohna Bridge
S10.	Mohna Drain	Domestic	28˚ 13' 26.50"	77˚27'20.70"	134	½ km up from Mohna Bridge (Faridabad downstream site)
S11.	Faridabad Downstream	Downstream	28˚ 13' 10.55"	77˚27'31.26"	129	Mohna Bridge (½ km down from Site S10)

The details of all the physico-chemical parameters, their systematic analytical techniques and methods and their appropriate instruments used to measure and compare the water quality parameters (mentioned in table 2) with the standards (permissible limits) given by WHO (World Health Organization) for drinking and irrigation purposes[2,4,7,10].

Table 2: Description of Physico-chemical parameters

Parameters	WHO	Analytical Methods	Instruments
Temperature (˚C)	-	Instrumental	Glass mercury thermometer
pH	6.5-8.5	Instrumental	Digital pH meter
Electrical Conductivity (µS/cm)	1400	Instrumental	Digital conductivity meter
Suspended Solids (mg/l)	-	Volumetric method	Glass filter (gravimetric)
Total Dissolved Solids (mg/l)	500	Volumetric method	Temperature controlled oven
Total solids (mg/l)	-	Volumetric method	-
Total Hardness (mg/l)	500	Titrimetric method	Titration Instrument
Calcium Hardness (mg/l)	-	Titrimetric method	Titration Instrument
Magnesium Hardness (mg/l)	-	Titrimetric method	Titration Instrument
Calcium (mg/l)	75	Titrimetric method	Titration Instrument
Magnesium (mg/l)	50	Titrimetric method	Titration Instrument
Chloride (mg/l)	200	Titrimetric method	Titration Instrument
Dissolved Oxygen (mg/l)	5	Winkler Iodometric method	Titration Assembly

RESULTS AND DISCUSSION

The seasonal variations of all the selected various physico-chemical parameters (Temperature, pH, EC, SS, TDS, TS, TH, CaH, MgH, Ca^{2+}, Mg^{2+}, Cl^{-} and DO) at all eleven sampling sites (from upstream to downstream) of Yamuna River in the Faridabad stretch are presented in table 3 and figure 3-15.

Table 3: Average concentration of selected physico-chemical parameters from May 2016 to April 2017

Seasons → / Parameters ↓	Summer	Monsoon	Post-Monsoon	Winter	Spring
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
Temp.	32.9±2.4	26.7±2.4	19.6±2.0	13.3±0.9	25.1±2.5
pH	7.7±0.4	8.1±0.3	8.5±0.2	8.1±0.2	7.8±0.3
EC	2389.5±728.8	1520.3±561.5	966.7±227.7	1742.6±513.1	2077.5±816.0
SS	510.0±112.5	289.6±72.3	172.7±49.4	547.8±100.7	387.8±119.1
TDS	1182.6±364.9	745.1±274.9	465.6±106.1	860.1±254.6	1019.8±390.1
TS	1692.6±464.7	1034.7±340.8	638.4±151.0	1407.9±346.5	1407.6±500.9
TH	865.0±185.2	526.8±97.2	383.6±93.9	785.5±146.0	743.2±158.8
CaH	547.7±131.4	220.9±82.1	147.7±45.7	294.1±84.5	245.5±77.8
MgH	317.3±65.2	305.9±39.4	235.9±58.4	490.9±71.1	497.7±84.0
Ca^{2+}	219.1±52.5	87.3±32.3	59.1±18.3	117.6±33.8	98.2±31.1
Mg^{2+}	77.1±15.9	74.3±9.6	57.3±14.2	119.3±17.3	120.9±20.4
Cl^{-}	328.1±112.8	213.2±108.9	175.5±92.9	374.5±79.8	289.5±119.3
DO	3.0±0.9	3.6±0.8	5.4±0.6	6.4±0.9	4.6±0.7

SD: Standard Deviation; **Min.:** Minimum; **Max.:** Maximum

Temperature

The temperature plays a vital role in physico-chemical and biological behavior of all aquatic bodies and appropriate for the survival and growth of fish fauna[11]. During the present study, the average temperature of all the seasons of collected water samples at all the eleven study sites were ranged between 13.3±0.9 ˚C to 32.9±2.4 ˚C (table 3). Minimum Temperature was recorded 12.2˚C at the site S11 (Faridabad Downstream) in winter season whereas the maximum was 36.4˚C at the site S5 (Budhia Nala, near Mozammabad Village) in summer season (figure 3). Change in temperature of water of river is due to the seasonal variations, the intensity and duration of sunlight, thermal power plant effluents, other industrial effluents and domestic sewage discharges directly into the river.

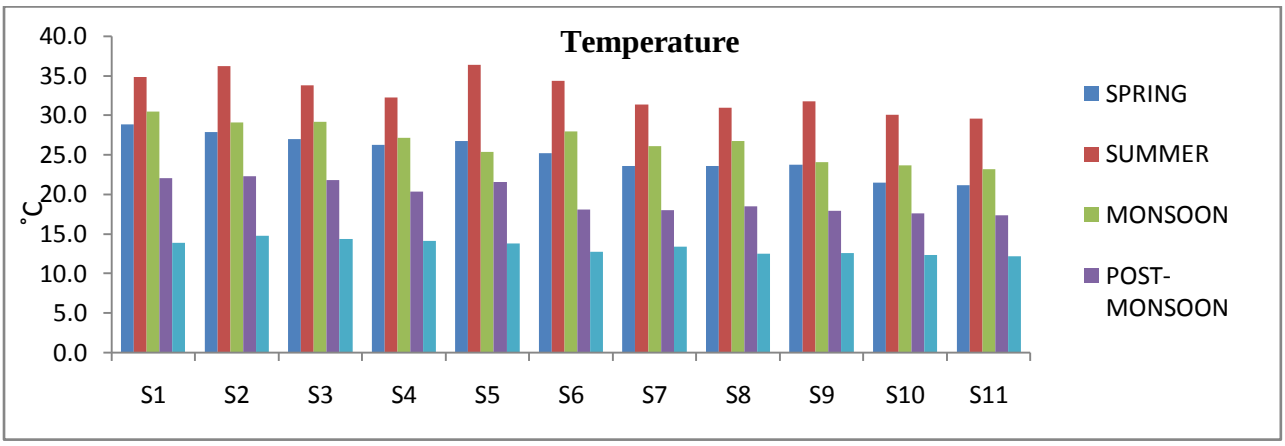

Figure 3: Seasonal variations of Temperature

pH

Generally the pH value of river's surface water varies due to changes in atmospheric temperatures, biological actions, industrial as well as domestic contamination[12]. In the present study average pH ranges of all the seasons at all the sampling sites have been recorded between 8.5±0.2 to7.7±0.4 (table 3). Minimum pH was recorded 6.8 at the site S5 (Budhia Nala) in summer season which was slightly acidic due to the addition of industrial effluents into the river Yamuna and maximum was observed 8.8 at the site S4 (No Drain-2) in post-monsoon season which was highly alkaline due to maximum dilution from rain water . The pH values at all the sites were found within the given standard limits (6.5-8.5) prescribed by WHO given in (table 2), except at sites S2, S3, S4, S5 and S9 which were slightly higher alkaline in post-monsoon season (figure 4). The pH values in different season across various study sites show minor differences among them, but overall found alkaline in nature at all the study sites during this study of Yamuna River.

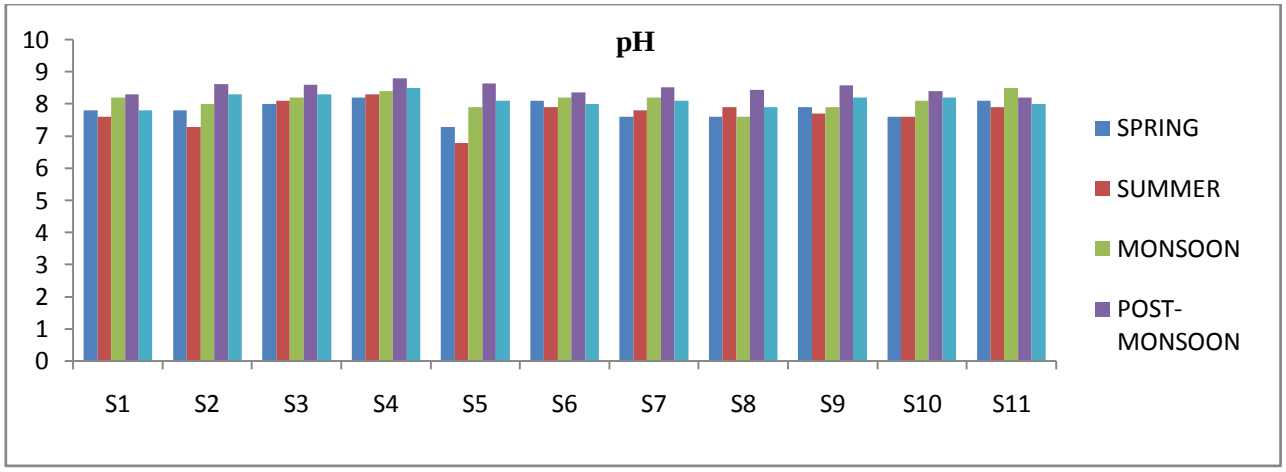

Figure 4: Seasonal variations of pH

Electrical Conductivity (EC)

EC is the determination of the capacity of water to carry out an electric current in water[6] and an important criterion of knowing the correctness of water for irrigation and agriculture activities[10]. Increase in the value of dissolved solids leads the higher amount of ions in water[13]. In this study, average conductivity was ranged from 966.7±227.7 µS/cm to 2389.5±728.8 µS/cm (table 3). Minimum EC was found 645 µS/cm at the site S4 (No Drain-2) in post-monsoon season due to dilution through rain water whereas maximum was recorded 3671 µS/cm at the site S2 (Basantpur Drain) in summer season. The EC values were detected above the permissible limits (1400 mg/l) prescribed by WHO (table 2), at all the sites in summer season, spring season (except S4), winter season (except S4 and S11) and monsoon season (except at sites S4, S6, S7, S8, S9, S10 and S11) demonstrated in figure 5**.** High values of EC during summer is mainly attributed to the discharge of agricultural run-off, industrial effluents and domestic sewage which meet into the river and increases the concentration of ions like Ca^{2+}, Mg^{2+}, Cl^{-} etc.

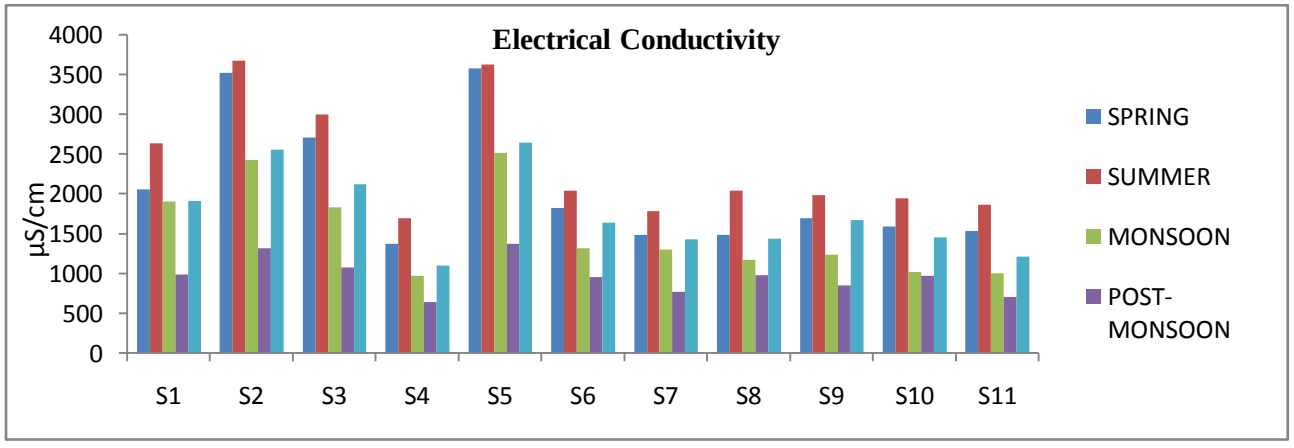

Figure 5: Seasonal variations of Electrical Conductivity

Suspended Solids (SS)

During the present study average suspended solids during all the seasons at different study sites were ranged 172.7±49.4 mg/l to 547.8±100.7 mg/l (table 3). Minimum was detected 80 mg/l at the site S4 (No Drain-2) in post-monsoon season because of dilution of water in rainy season while maximum was 694 mg/l at the site S5 (Budhia Nala) in winter season due to lower level of surface water of the Yamuna river (figure 6).

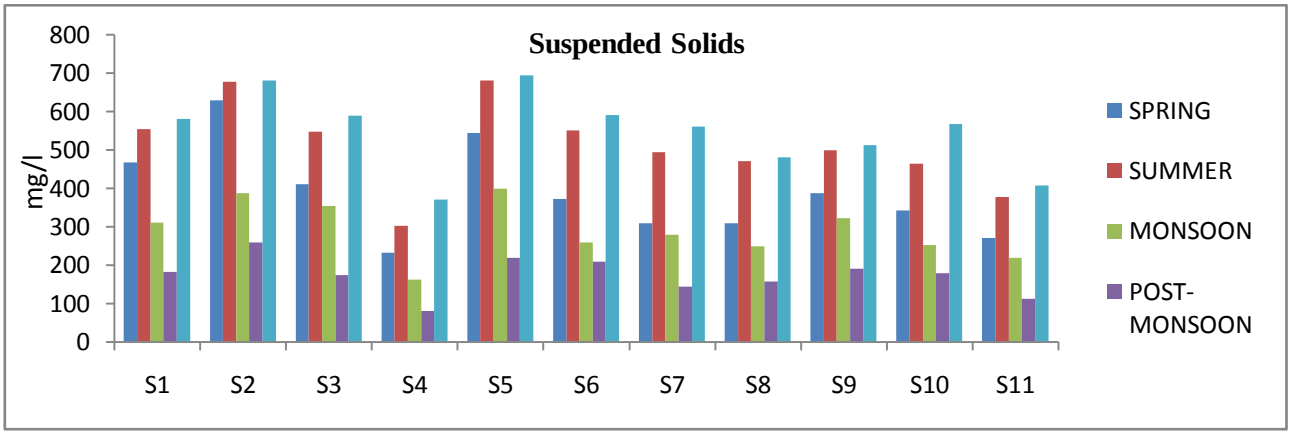

Figure 6: Seasonal variations of Suspended Solids

Total Dissolved Solids (TDS)

Usually TDS in water sample of water bodies does not harmful to individuals but at higher concentration of it may cause liver, heart and kidneys infections[12]. For this study, at all the study sites the average value of total dissolved solid were traced in the range between 465.6±106.1 mg/l to 1182.6±364.9 mg/l (table 3). Minimum was obtained 304 mg/l at the site S4 (No Drain-2) because of dilution in river water in post-monsoon season whereas maximum TDS was found 1827 mg/l at the site S2 (Basantpur Drain) in summer season. The value of TDS measured above the permissible limits (500 mg/l) prescribed by WHO, at all the sites in summer, winter, spring, monsoon season (except S4 and S11) and post-monsoon season (except sites S1, S4, S6 S7, S8, S9, S10 and S11) (figure 7). The value of TDS was found above the standard limits at all these sites due to heavily meeting of industrial drain and domestic sewage into the river.

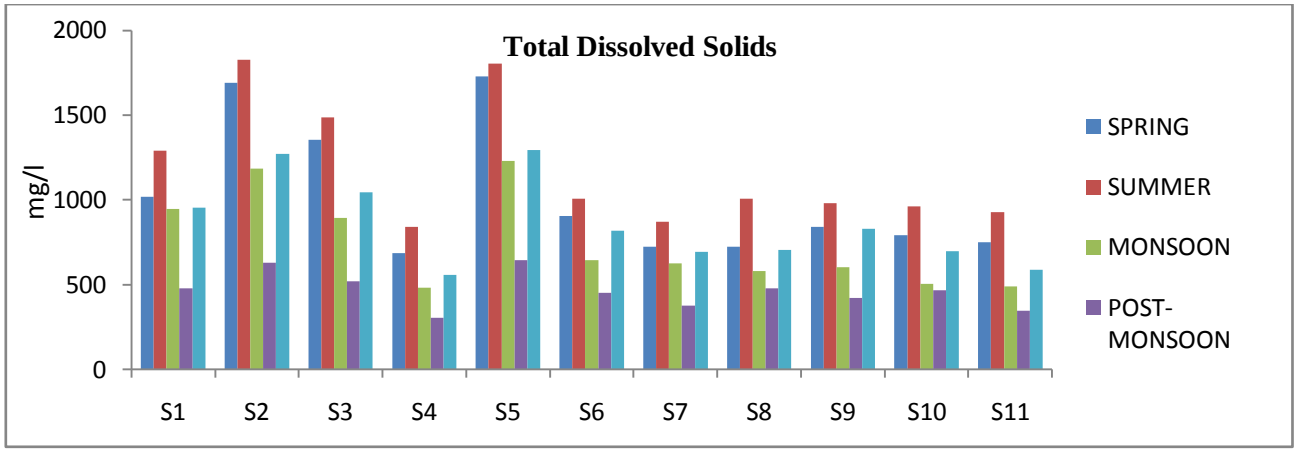

Figure 7: Seasonal variations of Total Dissolved Solids

Total Solids (TS)

In this study, average Total solids were ranged from 638.4±151.0 mg/l to 1692.6±464.7 mg/l (table 3). Minimum was 384 mg/l observed at the site S4 (No Drain-2) in post-monsoon season and maximum was 2503 mg/l at the site S2 (Basantpur Drain) in summer season (figure 8).

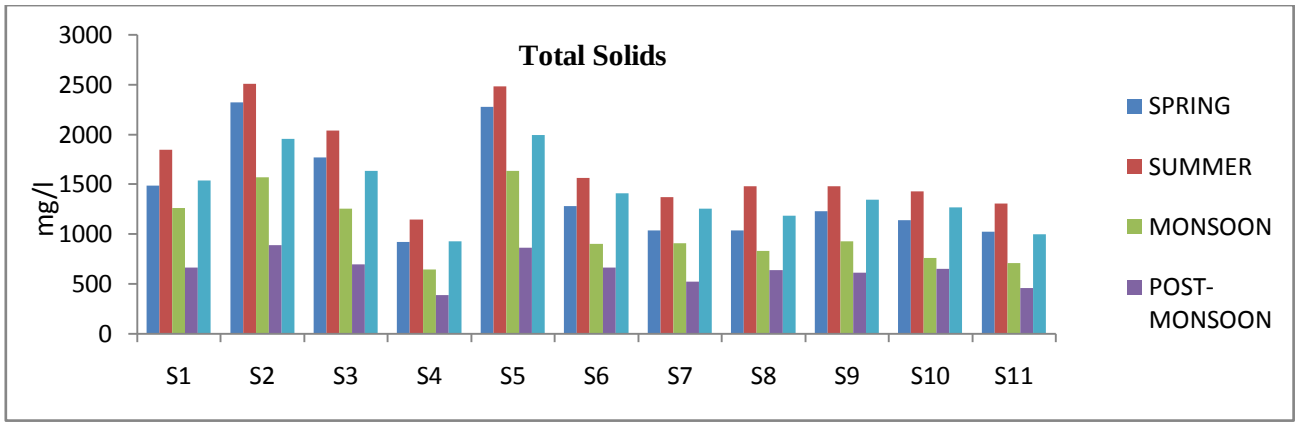

Figure 8: Seasonal variations of Total Solids

Total Hardness (TH)

Average Total Hardness of all the seasons at different study locations of Yamuna River was ranged in between 383.6±93.9 mg/l to 865.0±185.2 mg/l (table 3). Minimum TH was 215 mg/l recorded at the site S4 (No Drain-2) in post-monsoon season and maximum was 1215 mg/l at the site S2 (Basantpur Drain) in summer season. The total hardness of river water was observed above the permissible limits (500 mg/l) prescribed by WHO standards, at all the sites in summer, winter, spring, monsoon season (except at sites S4 and S11) and at site S5 in post-monsoon season (figure 9). Hardness in river water is through various types of rocks units and principally through discharging the industrial effluents which adding the higher amount of magnesium salts, calcium

salts, sulphate ions etc. and domestic wastewater which carries cooking waste, caustic detergents and soaps, human and cattle's wastes into river body.

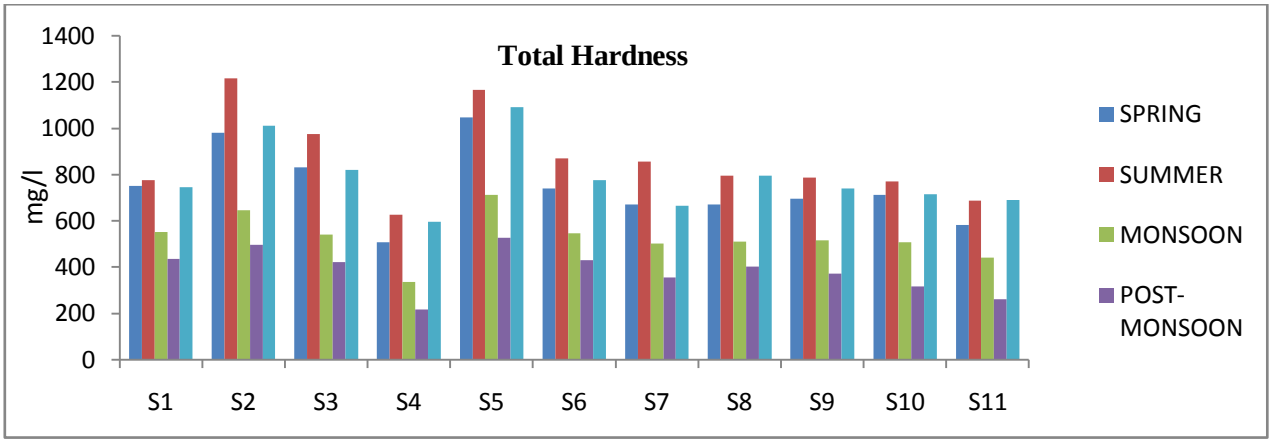

Figure 9: Seasonal variations of Total Hardness

Calcium Hardness (CaH)

At all the study sites, average values of CaH of all the seasons were ranged between 147.7±45.7 mg/l to 547.7±131.4 mg/l (table 3). Minimum value was obtained 70 mg/l at the site S4 (No Drain-2) in post-monsoon season and maximum was 780 mg/l at the site S5 (Budhia Nala) in summer season (figure 10).

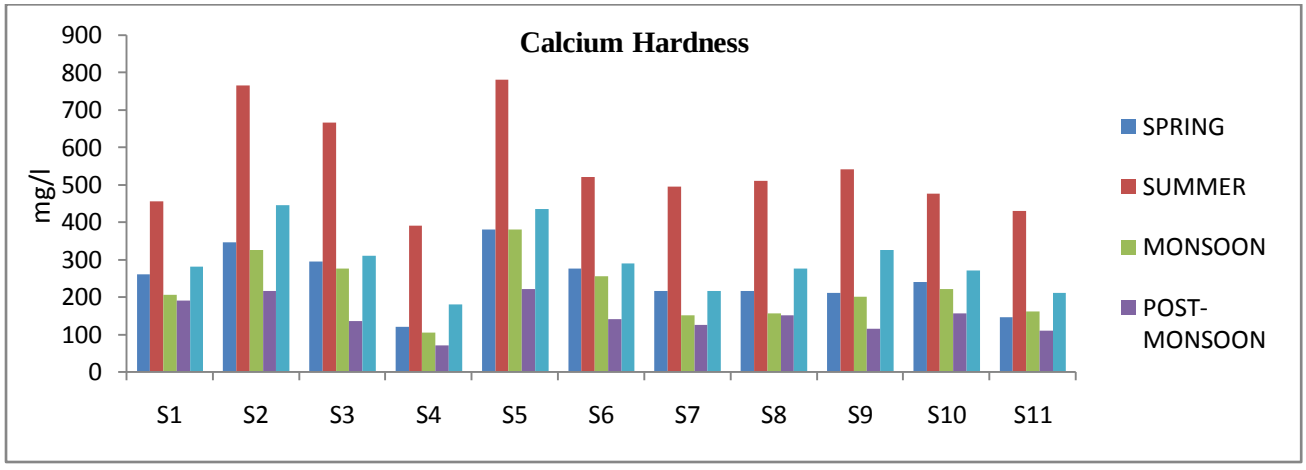

Figure 10: Seasonal variations of Calcium Hardness

Magnesium Hardness (MgH)

MgH in water is due to the occurrence of sulphate ions in it. Higher the concentration of sulphate ions causes laxative consequence on beings who consume it[12]. At all the study sites, average magnesium hardness was assessed in the range of 235.9±58.4 mg/l to 497.7±84.0 mg/l (table 3).

Minimum value of MgH was found 145 mg/l at the site S4 (No Drain-2) in post-monsoon season whereas maximum was 665 mg/l at the site S5 (Budhia Nala) in spring season (figure 11).

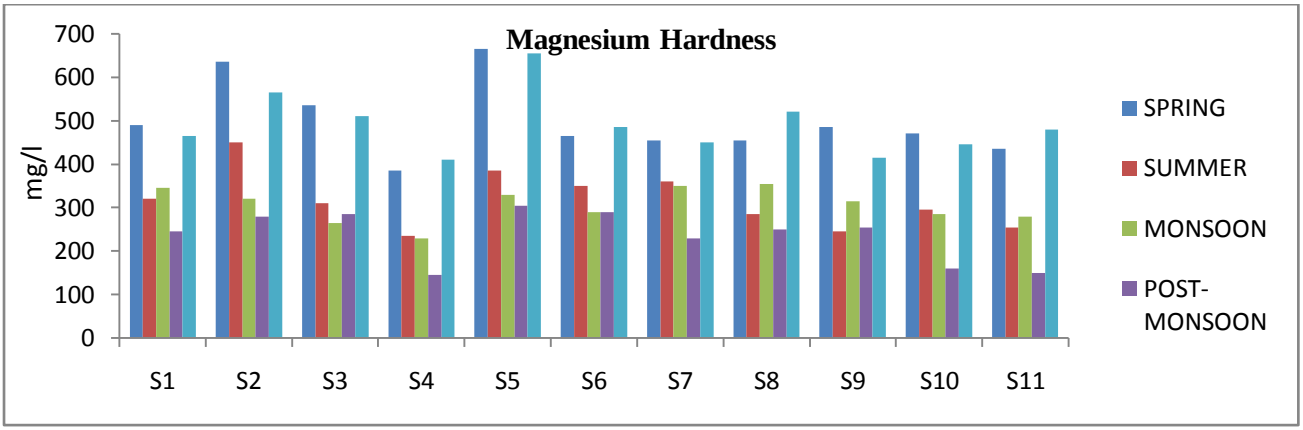

Figure 11: Seasonal variations of Magnesium Hardness

Calcium (Ca^{2+})

At different study sites, recorded average calcium value of all the seasons for this study was ranged from 59.1±18.3 mg/l to 219.1±52.5 mg/l (table 3). Minimum was observed 28 mg/l at the site S4 (No Drain-2) in post-monsoon season while maximum 312 mg/l at the site S5 (Budhia Nala) in summer season. The values of calcium were recorded above the permissible limits (75 mg/l) of WHO standards, at all the sites in summer, winter (except at site S4), spring (except at sites S4 and S11), monsoon season (except at sites S4, S7, S8 and S11) and post-monsoon season (except at sites S3, S4, S6, S7, S8, S9, S10 and S11) (figure 12).

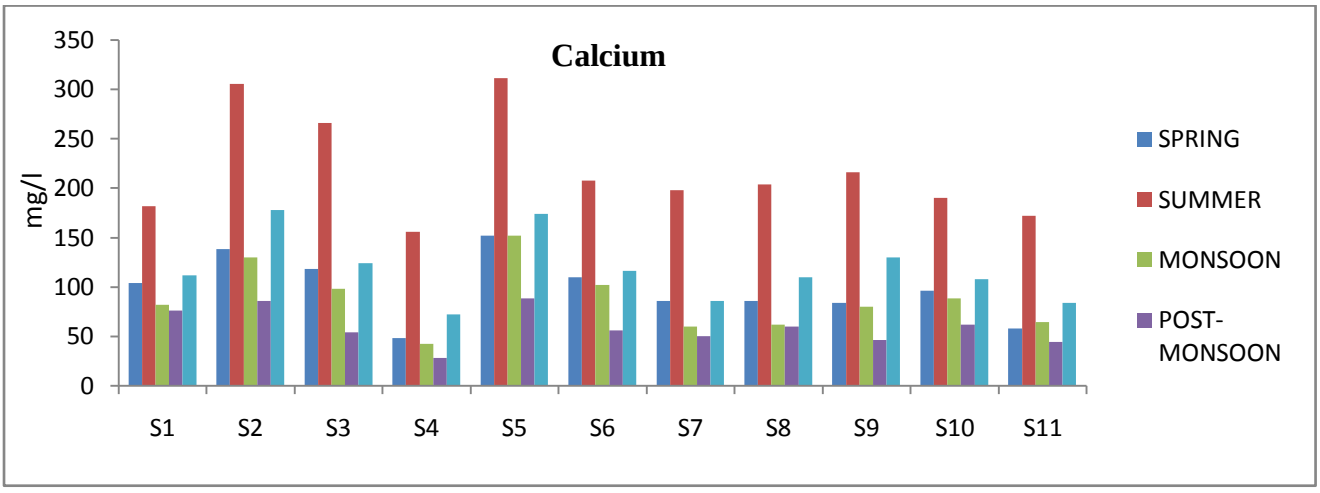

Figure 12: Seasonal variations of Calcium

Magnesium (Mg^{2+})

Average magnesium value of all the seasons of water samples at different study stretch of Yamuna River was measured in the range of 57.3±14.2 mg/l to 120.9±20.4 mg/l (table 3). Minimum magnesium was obtained 35.2 mg/l at the S4 (No Drain-2) in post-monsoon season whereas maximum was recorded 161.6 mg/l at the site S5 (Budhia Nala) in spring season. The magnesium was traced above the permissible limits (50 mg/l, according to the WHO, at all the study locations in summer, monsoon winter, spring and post-monsoon season (except at the sites S4, S10 and S11) (figure 13).

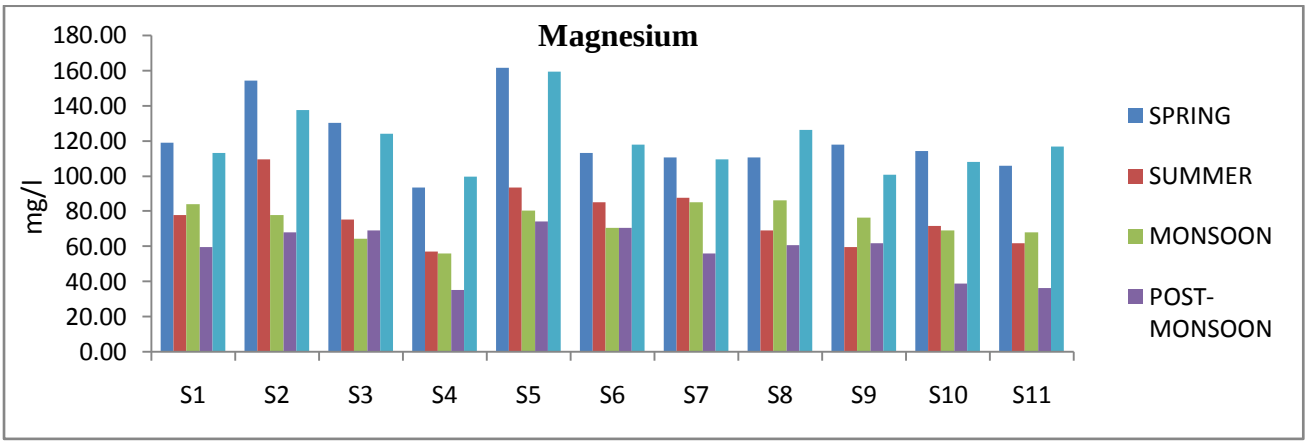

Figure 13: Seasonal variations of Magnesium

Chloride (Cl^-)

In this present study, the average value of chloride of all the seasons of water samples at different study sites was recorded in range of 175.5±92.9 mg/l to 374.5±79.8 mg/l (table 3). Minimum was 85 mg/l recorded at the site S4 (No Drain-2) in post-monsoon season due to dilution in river water through rains and maximum was 549.8 mg/l at the site S5 (Budhia Nala) in summer season due to accumulation of industrial effluents. The chloride value were obtained above the given standard limits (200 mg/l) according to the WHO, at all the sites in winter season, summer season (except at sites S4 and S11), spring season (except at sites S4 and S11), post-monsoon season (except at sites S1, S3, S4, S6, S7, S, S9, S10 and S11) and monsoon season (except at sites S4, S6, S7, S8, S9 S10 and S11) (figure 14). The higher amount of chloride traced in river body due to receiving of untreated industrial effluents, domestic sewage and agricultural run-off which adding the harmful fertilizers into the river.

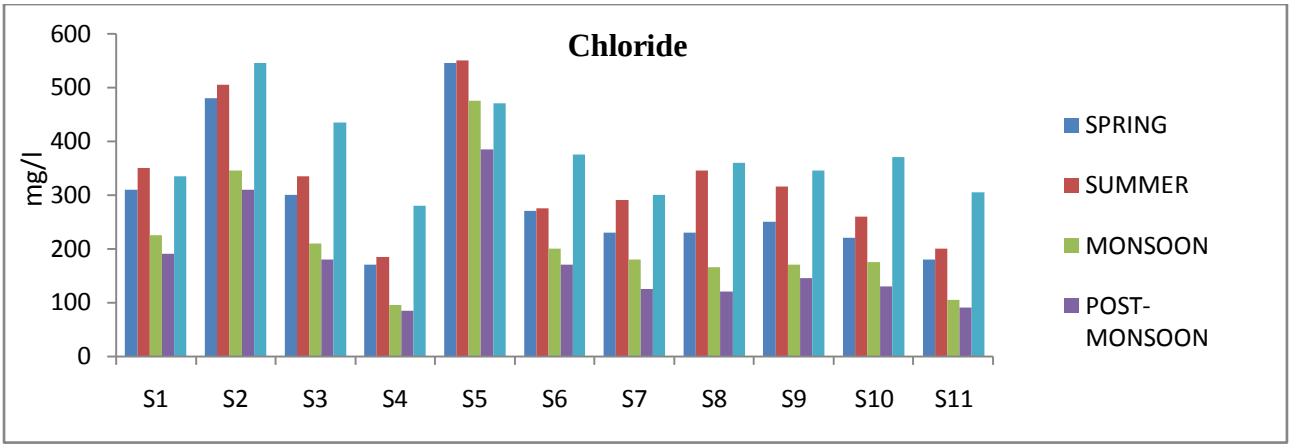

Figure 14: Seasonal variations of Chloride

Dissolved Oxygen (DO)

Dissolved oxygen has great significance to all the living organisms dwelling in water bodies and is considered to be the sole indicator parameter which is to a major extent can expose and support the environment of whole aquatic body[14]. A well dynamic and healthy river should have minimum 5 mg/l of dissolved oxygen which is very much essential for the existence and survival of aquatic life[8]. The average DO value of water samples of all the season at different study sites were recorded in the range of 3.0±0.9 mg/l to 6.4±0.9 mg/l (table 3). Minimum was 1.9 mg/l found at the site S5 (Budhia Nala) in summer season and maximum was 7.9 mg/l at the site S11 (Faridabad Downstream) in winter season. The values of dissolved oxygen were recorded below the permissible limits (5 mg/l) by WHO, at all the sites in summer season, monsoon season, spring season (except at sites S4, S10 and S11) and at sites S2 and S5 in post-monsoon season (figure 15). Due to outer atmosphere and the process of photosynthesis done by aquatic phytoplankton the oxygen present into the river. All the aquatic living organisms dwelling in the river requisite adequate quantity of dissolved oxygen for their utilization, growth and continued existence. But in the above mentioned sites, the amount of dissolved oxygen were depleted due to addition of effluents from various industries, domestic wastewater, agricultural wastes which causes the death of fish fauna and other aquatic dwellers.

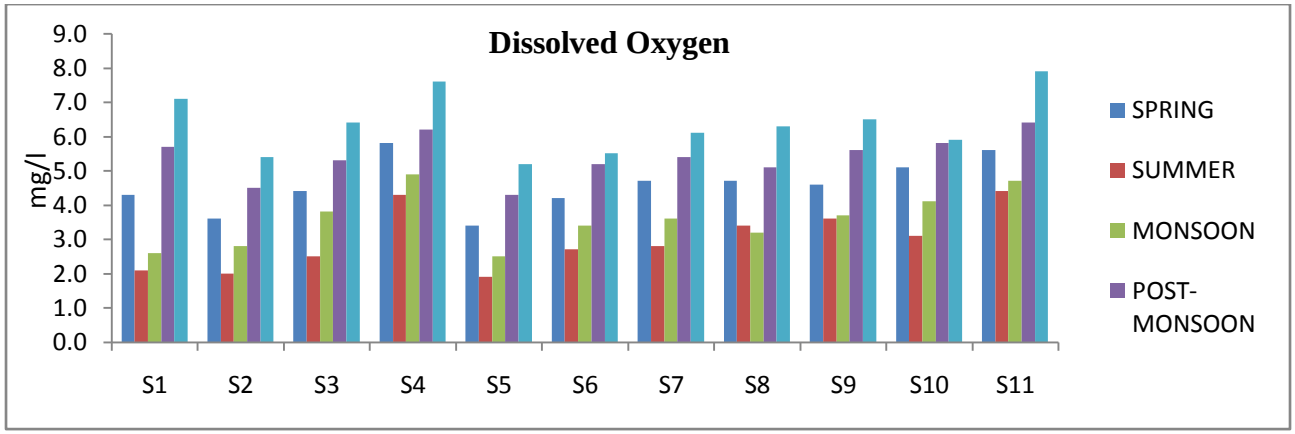

Figure 15: Seasonal variations of Dissolved Oxygen

CONCLUSIONS

The observations and results obtained from the above present study indicated that the surface water quality of River Yamuna is heavily polluted at all the drain sites especially Site 2 and Site 5 (both are industrial drain sites) in comparison to no drains (S3 and S4) sites. The effluents carried out from industrial drains (S2 and S5) and domestic drains (S6, S7, S8, S9 and S10) released into the river without prior treatment, have the greatest impact on the worst water quality of river. Across different seasons it can also be concluded that all the parameters at approx. all the sites were found above the permissible value as per the WHO standards except in post-monsoon season because of dilution due to increase in river's water volume through rains when compared with rest other seasons. But the overall, the surface water of River Yamuna is not good and safe for drinking and other household purposes as the river water's excellence lies under the very poor status. Day by day increase in the concentration of toxic elements into river body makes the river's water unfavorable for all the aquatic creatures specially fish fauna. This present assessment reflected that the primary identified sources of pollution were human beings inputs, cattle inputs, domestic sewage water, agricultural and farms runoff and most important the industrial wastewater which leads to the quality of river's water at alarming stage of dead position which required careful timely monitoring and strictly followed better management practices. This kind of work has never happened before at Faridabad, so this study could be taken as a baseline for investigating further changes and could be very helpful in the restoration, management and treatment of this river body for its water quality and biodiversity at Faridabad. A clean and healthy river is a very important issue; hence, best possible remedial measures should be adopted and strictly pursued for enhancing the water's quality of river Yamuna in Faridabad.

ACKNOWLEDGEMENTS

The authors are thankful and gratefully acknowledge the UGC (University Grant Commission) for providing financial assistance and Haryana State Pollution Control Board, Faridabad region for providing laboratory facilities and also thankful to Dr. Aisha Sultana for her guidance and encouragement during the study.

REFERENCES

1. Ishak F and Khan A. Aquatic Biodiversity as an ecological indicator for Water Quality Criteria of River Yamuna in Doon Valley, Uttarakhand, India. *World Journal of Fish and Marine Sciences.* 2013; 5(3): 322-334.
2. Kumar A, Sharma RC and Rathore B. Determination of WQI of River Yamuna between Mathura and Agra region. *Ultra Chemistry*. 2015; 11(1): 7-14.
3. Laxmi R, Arya S, Das S and Sultana A. Assessment and Impact of Industrial effluents on River Yamuna Ecosystem. *International Journal of Current Affairs*. 2015; 7(9): 19956-63.
4. Hassan T, Parveen S, Bhat BN and Ahmad U. Seasonal Variations in Water Quality Parameters of River Yamuna, India. *International Journal of Current Microbiology and Applied Science*. 2017; 6(5): 694-712.
5. Rani M and Bhamrah HS. Seasonal variation in biological water quality in ecological segments of river Yamuna. *Journal of Entomolog and Zoology Studies*. 2014; 2(3): 231-235.
6. Parmar KS and Bhardwaj R. Water quality management using statistical analysis and time series prediction model. *Journal of applied Water Sciences*. 2014; 4: 425-434.
7. Sharma SK and Chhabra MS. Understanding the chemical metamorphosis of Yamuna River due to pollution load and human use. *International Research Journal of Environmental Sciences*. 2015; 4(2): 58-63.
8. CPCB. Water quality status of Yamuna River. Central Pollution Control Board, Ministry of Environment and Forest. Assessment and Development of River Basin Series. (1999-2005); ADSORBS/41/2006-7.
9. APHA, WEF, AWWA. Standard methods for the examination of water and wastewater. 22th edition. 2012; Washington D.C.
10. Kumar M and Puri A. A review of permissible limits of drinking water. *Indian Journal of Occupational and Environmental Medicine.* 2012; 1(2): 53-55.

11. Shukla MK, Khare PK and Singh R. Hydro-biological Study of the Yamuna River at Kalpi, District Jalaun, Uttar Pradesh, India. *Hydro Nepal Journal of Water Energy and Environment.* 2016; 18: 41-46.
12. Amaliya NK and Kumar SP. Evaluation of surface water quality of Kanyakumari district through water quality index assessment. *International Journal of Plant, Animal and Environmental Sciences.* 2014; 4(1): 73-77.
13. Kumar V, Arya S, Dhaka A, Meenakshi and Chanchal. A Study on Physico-chemical Characteristics of Yamuna River around Hamirpur (UP), Bundelkhand Region Central India. *International Multidisciplinary Research Journal.* 2011; 1(5): 14-16.
14. Kaur I and Verma DD. Physico-chemical and microbiological study of river water of Ganga and Yamuna in Allahabad. *Asian Journal of Science and Technology*. 2014; 5(11): 669-673.