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Seasonal Dynamic of Physicochemical Parameters of Berach River System in Udaipur District, Rajasthan

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Abstract

Surface and ground water have been contaminated is a result of the improper disposal of industrial and municipal waste. Seasonal variations in human interference and natural processes particularly rainfall and temperature have an impact on the water quality of aquatic ecosystems. During the study, Sarjana tank showed the lowest average value of water temperature, 25.31ºC, whereas Gadwa pond had the maximum average value of water temperature (28.25ºC). The highest depth of visibility observed in Bada Madar tank (104cm) in winter 2019 and lowest depth of visibility observed in downstream pond (9.2cm) in monsoon 2019. Industrial pollution was responsible for comparatively low pH in the ponds of Berach river viz Upstream, Downstream, Gadwa, Daroli pond and Sarjana tank. The maximum average dissolved oxygen was found in Fatehsagar lake and minimum average dissolved oxygen found in Daroli pond. Udaisagar lake had highest alkalinity of 324.00 mg/l during winter 2018 and the lowest value of 68mg/l was observed in Down-stream pond in winter 2019. Chhota Madar tank had the lowest average hardness value of 136.61 mg/L. The highest mean conductivity (3.1018 m.mhos.) value was observed in the Down-stream pond and the lowest mean conductivity (0.3178 m.mhos.) in Chota Madar pond. Lowest TDS value (151.8 ppm) was in Bada Madar tank during the monsoon of 2018 and highest (4999.2 ppm) was in the downstream pond during winter 2018. Lowest mean chloride was found in Fatehsagar lake while highest mean chloride was found in downstream pond. Chhota Madar tank was found to be most rich in phosphates (0.4856 mg/l).

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1. Introduction

Water demand has increased significantly in recent years as a result of population, agricultural and industrial growth. Surface and ground water are contaminated due to improper disposal of waste materials, industrial and municipal waste. Several health problems and diseases are caused by consumption of contaminated water available for drinking and household purposes with harmful bacteria, heavy metals, metal ions and other pollutants[1]. The quality of water is influenced and determined by several physico-chemical parameters, which greatly depend on a variety of factors such as the source of water, seasonal variations, nature of pollutant, types of chemical and anthropogenic interference[2]. The physico-chemical properties of water, as well as its biological diversity are essential for maintaining a healthy aquatic ecosystem[3]. A freshwater body's physico-chemical characteristics have a significant impact on its biota. The physico-chemical parameters as well as the biotic communities of India's lentic and lotic water bodies have been extensively studied by[4,5]. Several studies have been conducted on the pond ecosystem and its physico-chemical properties[6–12]. Water, a renewable natural resource, is an essential resource for any nations for development of socioeconomic[13]. Humans choose residential areas based on the availability and quality of reliable water resources. Appropriate water management is the key to unlocking economic growth and social well-being[14]. Because every organism in an ecosystem requires water to survive, water is an essential component of the ecosystem[15,16]. Human activities, industrialization, poor sanitation facilities, sewage and waste disposal have contributed to the contamination of freshwater bodies[17]. According to Toyobo and Tanimowo[18], 1.1 billion human beings do not receive safe and good quality water for drinking purposes in the world. Heavy metals, salts and harmful microbes have contaminated the water supply system[19]. Contamination of water has a variety of negative health consequences for humans, including the transmission of water-borne diseases[20]. The chemical and physical properties of water and water bodies are influenced by various environmental and physical factors, namely climatic conditions, geochemical levels of pollution in surrounding areas and the geomorphological conditions of surface water[21]. Several studies have been also made upon various limnological parameters of fresh water ecosystems of various part of country[22–26]. Surface water is also polluted due to contamination of heavy meats, agrochemical pesticides and industrial waste discharges in water bodies[27,28]. Greater concentration of nutrients like nitrogen and phosphorus leads to hypoxic and algal bloom conditions in water bodies, which may cause serious loss of biodiversity, low level of oxygen's availability, low light penetrations, mortality of aquatic organisms in water bodies[29–31]. Fresh water and riverine ecosystems face threats from excessive anthropogenic made activities such as industrialization and agricultural drainage systems[32,33]. Anthropogenic activities such as agrochemical pollutants, untreated sewage water and industrial effluents are major sources of water pollution and quality degradation[34–36]. Seasonal variation in human and natural processes, especially rainfall and temperature, influences the water quality of aquatic ecosystems[37,38]. Various studies have been conducted on the limnological status and trophic structure of freshwater bodies by [6,39,40]. Several studies on the limnology of Udaipur water have been conducted, covering physico-chemical features, phytoplankton and primary production by[6,7,8,41]. In India, several rivers and riverine ecosystems are affected by pollution and contaminated by heavy metals, metal ions, nutrients (nitrogen and phosphorus) and industrial wastes. The results of pollutants are also responsible for changes in the physicochemical properties of waters[42–48].

During study we analyzed physicochemical parameter of nine water bodies namely Bada Madar and Chhota Madar tank, Fatehsagar lake, Udaisagar lake, Upstream pond, Down-stream pond, Gadwa pond, Daroli pond and Sarjana tank of Berach river system in Udaipur district Rajasthan. Water samples of Berach river system was analysed for different physicochemical parameters-water temperature, depth of visibility, pH, dissolved oxygen, total alkalinity, hardness, electrical conductivity, total dissolved solids, chlorides, nitrate, phosphate and sulphate.

2. Material and Methods

During the present study some selected physico-chemical parameters such as temperature, pH, conductivity, depth of visibility, alkalinity, total dissolved solids, chlorides, total hardness, phosphates, nitrates and sulphates have been undertaken. These physico-chemical estimations have

been done after[49]. For the measurement of temperature a centigrade thermometer was used. For measuring depth of visibility a standard sacchi disc of 20 cm. diameter was used and pH of water was estimated in the field using digital pH meter. Total dissolved solids and electrical conductivity and temperature in the field was estimated by digital (Wissenschaftich Technische Werkstatten) WTW meter. Total hardness, chlorides, alkalinity, dissolved oxygen were determined by titration method, while nitrates, phosphates and sulphates were estimated by Systronics digital spectrophotometer. Electrical conductivity was measured by digital conductivity meter and results were expressed as milli mhos at 25 °C.

3. Results and Discussion

During the present study we observed various physico-chemical parameters of selected nine water bodies of Berach river system of Udaipur district along with their inter-relationship (Tables 1, 2 and 3).

3.1 Water Temperature

All chemical and biological processes in water bodies are controlled by changes in temperature. Metabolism of aquatic organisms is known to be enhanced two fold with the increase of 10 °C in the ambient temperature. Further this key factor has been used to classify lakes as gradation of water temperature causes thermal stratification and circulation in water bodies. Water temperature ranged between 19.1 °C to 34 °C during present study. Among all selected water bodies, Chhota Madar tank showed these values of minimum in winter 2019 (19.1°C) and maximum in summer 2018 (34°C). But when year-wise comparison has been made Udaisagar lake had minimum water temperature (20.4°C) during winter of 2018. However, maximum water temperature was noted in lake Fatehsagar (32.8 °C) during summer season of 2019. Table 1 depicts season-wise water temperature in all nine water bodies. Biannual average values of water temperature have been compared in the case of eight water bodies as Daroli pond got dried during summer season of 2018 and 2019. Out of eight water bodies compared, Sarjana tank (Vallabhnagar) showed lowest average value of water temperature i.e. 25.31 °C, whereas Gadwa pond had maximum average water temperature (28.25 °C). Relatively high water temperature of this pond may be due to its shallowness and small water spread area.

3.2 Depth of Visibility

Light penetration in water bodies is also affected by turbidity which may be caused by suspended particles and planktonic organisms. Domestic and industrial pollutants tend to reduce depth of visibility by increasing turbidity and hence these parameters give first-hand information regarding water quality and trophic status of a water body. As indicated in Table 1; this parameter exhibited marked variation in different water bodies and during different seasons in the same water body. This revealed that Bada Madar tank had highest average value of 79.95 cm and Downstream pond had lowest average value of 13.10 cm. Season- wise values of all water bodies showed that highest depth of visibility was 104 cm observed during winter 2019 in Bada Madar tank. Whereas lowest depth of visibility was 9.2 cm in Down-stream pond during monsoon season of 2019. In general turbidity increased during monsoon season and in winter water used to become clear. However, during summer heavy evaporation of water was responsible for concentration of suspended and dissolved impurities which again reduced water clarity. During study depth of visibility showed positive correlation with dissolved oxygen and pH (Table 3). Relationship was found negative with sulphates, chlorides, hardness, electric conductivity, TDS, nitrates, total alkalinity and phosphates.

3.3 pH

It is a negative logarithm of hydrogen ion concentration. It is an important chemical factor influencing biological activities and trophic status of a water body. But different types of pollutants are known to alter water pH and also affect water quality and productivity of receiving water bodies. All nine water bodies undertaken for study maintained slightly acidic to alkaline pH during different season of study period where in the values fluctuated between 6.4 and 9.1 (Table 1). On the basis of average values depicted in (Table 2), Daroli pond had water with lowest pH (4.48) whereas pH of water in Fatehsagar lake was highest (8.5) during the study period of 2018-19. According to seasonal variation in pH; Fatehsagar lake had highest pH value (9.1) in monsoon season, 2019 while lowest pH value (6.4) observed from Daroli pond

Table 1. Seasonal variation in physicochemical parameters in water bodies belonging to Berach river system during 2018–19

Location	Duration	Water temperature	Visibility	pH	DO	Alkalinity	Hardness	Conductivity	TDS	Chloride	Nitrate	Phosphate	Sulphate
Bada madar tank	Winter-18	23	94.5	7.8	8.9	140	161	0.785	471	189	0.121	0.0641	54.66
	Summer-18	32	72	8.2	4.3	138	142	0.12	720	156	0.218	0.0872	29.87
	Monsoon-18	27.2	61	8.4	4.9	113	262	0.253	151.8	93	0.34	1.0115	53.11
	Winter-19	20.6	104	7.8	6.4	124	156.3	0.497	298.2	100	0.197	NIL	58.9
	Summer-19	28.1	79.2	8	4.7	102	206	0.267	160.2	97	0.31	0.6745	43
	Monsoon-19	24.6	69	7.8	4.6	128	137	0.114	684	67	0.43	0.095	47.17
Chhota Madar tank	Winter-18	23	76	7.7	7.6	106	150	0.458	274.8	201	0.21	0.05441	41
	Summer-18	34	69.1	8.4	4.2	117	128	0.289	298	172	0.29	0.0899	37.46
	Monsoon-18	26.9	54	8.1	5.9	121	146	0.278	168	86	0.38	0.5743	19
	Winter-19	19.1	58	8.7	5.6	96	164.7	0.341	204.6	182	0.27	0.03285	67
	Summer-19	28.1	62.2	7.8	5.2	119	70	0.244	146.4	126	0.34	0.9218	49
	Monsoon-19	27.2	62	8	5.4	138	161	0.297	149	52	0.37	1.2401	21
Fateh sagar lake	Winter-18	21.2	85	8.2	8.2	120	140.8	0.389	233.4	70	0.47	0.2	14
	Summer-18	29.8	79	8.1	6.4	112	148	0.51	318	65	0.35	0.49	16
	Monsoon-18	23.2	72	8.8	7.8	128	129	0.452	276	62	0.46	1.02	26
	Winter-19	20.1	59.4	8.6	8.1	156	162	0.44	279	51	0.44	NIL	19
	Summer-19	32.8	83	8.2	5.7	121	136.2	0.51	327	74	0.121	NIL	31
	Monsoon-19	28.4	76	9.1	5.8	132	156	0.46	282	79	0.31	NIL	15
Udai sagar lake	Winter-18	20.4	68	8.4	7.8	324	264	0.1782	962	268	0.53	0.4	46.8
	Summer-18	28.9	51.2	8.5	5.8	289	274	1.548	851	296	1.02	NIL	63
	Monsoon-18	21.4	54.1	7.8	5.7	292	272	0.982	527	177	0.88	0.54	84
	Winter-19	22.6	68.6	7.9	5.9	308	236	0.26	1560	280	0.2	0.7	52.32
	Summer-19	29.1	54.6	7.8	4.8	182	208	1.132	679.2	272	0.43	0.692	82
	Monsoon-19	30.1	44.8	8.1	5.9	286	236	0.2	1200	260	0.367	NIL	62.12

Table 1 continued.

Up stream pond	Winter-18	24	62	7.5	7.04	273	312	0.1964	1178.4	439	0.38	NIL	27.2
	Summer-18	30.4	42.3	8.1	5.2	291	585	3.124	1874.4	314	0.27	0.1	98
	Monsoon-18	24.6	54	7.8	5.7	289	392	0.4221	2532.6	472	0.41	NIL	257
	Winter-19	21	67	7.6	6.9	312	486	0.79	4345	486	0.257	0.2	126
	Summer-19	29.6	45.3	7.9	5.5	246	454	3.4	2280	654	0.42	NIL	146
	Monsoon-19	25.1	44.1	8.2	5.8	302	374	0.3976	2385.6	367	0.42	0.4	167
Down stream pond	Winter-18	26	19	7.2	3.8	148	1125	2.495	2554.2	447	0.312	NIL	1542
	Summer-18	32.1	14	7.8	4.16	288	389	3.542	4124	527	0.332	NIL	1347
	Monsoon-18	27.4	11	6.4	5.3	108	1794	4.482	2673	628	0.21	0.43	1628
	Winter-19	24	12	6.5	7.2	68	1040	3.362	4999.2	620	0.592	0.27	1452
	Summer-19	31.8	13.4	8.8	5.9	206	436.8	1.66	3660	640	0.357	NIL	1714
	Monsoon-19	24	9.2	7.4	5.1	129	1327	3.07	2917.8	518	0.218	0.71	1979
Gadwa	Winter-18	27	29.4	7.5	5.4	131	863.4	3.1	1772.4	388	0.441	0.12	1356
	Summer-18	30.6	34	8.1	4.1	212	1345	3.46	2950	568	0.358	0.38	1526
	Monsoon-18	28.4	26.3	7.2	4.9	139	986.45	3.28	1968	403	0.251	0.22	1480
	Winter-19	24.3	31.8	7.7	6.5	172	764	2.68	1609.2	481	0.269	NIL	1284
	Summer-19	30	32	8.4	4.6	237	1586	2.27	3459	502	0.468	0.28	1288
	Monsoon-19	29.2	27.3	7.3	5.2	154	812	3.8	1792.8	390	0.281	0.21	1840
Daroli pond	Winter-18	27	68.4	6.9	5.7	127	863.4	1.83	1098	96	0.64	NIL	438
	Summer-18	-	-	-	-	-	-	-	-	-	-	-	-
	Monsoon-18	28.4	39.8	6.4	4.9	142	879	2.83	688.2	387	0.227	0.4	322
	Winter-19	24.3	59.7	6.7	6.7	184	478	1.17	703.2	481	0.321	NIL	428
	Summer-19	-	-	-	-	-	-	-	-	-	-	-	-
	Monsoon-19	29.2	50	6.9	5.1	158	578	2.51	816	321	0.33	NIL	253
Sarjana tank	Winter-18	24.7	81	7.8	7.9	164	245	0.1742	1045.2	198	0.214	0.05	58.1
	Summer-18	29.7	74.296	8.2	5.5	187	297	2.92	1272	232	0.322	0.2	86.22
	Monsoon-18	22	54.2	7.3	5.12	128	224	0.19	1140	120	0.549	NIL	305
	Winter-19	21.4	79.2	7.5	6.6	176	216	0.1876	1125.6	330	0.122	NIL	69.78
	Summer-19	28.5	68	7.8	6.2	182	312	1.983	1352	186	0.331	0.02	278
	Monsoon-19	25.6	52.6	7.4	5.9	96	231	0.1782	1089	109	0.417	0.05	226

Table 2. Averages values of different physicochemical parameters observed in different water bodies of Berach river system during 2018–19

Location	Water Tempe-rature	Visibility	pH	DO	Alkalinity	Hard-ness	Conduc-tivity	TDS	Chloride	Nitrate	Phosphate	Sulphate
Bada madar tank	25.9167	79.95	8	5.6333	124.1667	177.3833	0.3393	414.2	117	0.2693	0.3221	47.785
Chota Madar tank	26.3833	63.55	8.11	5.65	116.1667	136.6167	0.3178	206.8	136.5	0.31	0.4856	39.0767
Fateh sagar lake	25.9167	75.7333	8.5	7	128.1667	145.3333	0.4602	285.9	66.8333	0.3585	0.285	20.1667
Udai sagar lake	25.4167	56.8833	8.08	5.9833	280.1667	248.3333	0.7167	963.2	258.8333	0.5645	0.3887	65.04
Up stream pond	25.7833	52.45	7.85	6.0233	285.5	433.8333	1.3884	2432.667	455.333	0.3595	0.1167	136.8667
Down stream pond	27.55	13.1	7.35	5.2433	157.8333	1018.6333	3.1018	3488.033	563.3333	0.3368	0.235	1610.333
Gadwa pond	28.25	30.1333	7.7	5.1167	174.1667	1059.475	3.0983	2258.567	454	0.3447	0.2017	1462.333
Daroli pond	18.15	36.3167	4.4833	3.7333	101.8333	466.4	1.39	550.9	214.1667	0.253	0.0667	240.1667
Sarjana tank	25.3167	68.2993	7.667	6.2033	155.5	254.1667	0.9388	1170.633	195.8333	0.3258	0.0533	170.5167

Table 3. Correlation among different physicochemical parameters of water bodies belonging to Berach river system based on seasonal variation during 2018–19

	Water tempe-rature	Visibility	pH	DO	Alkal-inity	Hard-ness	Conduc-tivity	TDS	Chloride	Nitrate	Phosphate	Sulphate
Water temp	1	-0.2743	0.0884	-0.6152	-0.0109	0.1678	0.358	0.1286	0.1563	-0.0819	-0.0098	0.2141
Visibility	-	1	0.3414	0.4396	-0.1267	-0.7323	-0.7303	-0.7053	-0.7452	-0.1473	-0.04	-0.836
pH	-	-	1	0.1935	0.1935	-0.5055	-0.4588	-0.2758	-0.3884	0.1008	0.1397	-0.3656
DO	-	-	-	1	0.0171	-0.3369	-0.3451	-0.1844	-0.1887	0.0062	-0.1422	-0.33
Alkalinity	-	-	-	-	1	-0.0165	0.028	0.3577	0.3781	0.2577	-0.018	-0.0857
Hardness	-	-	-	-	-	1	0.7887	0.6375	0.6934	-0.0266	-0.0781	0.8184
conductivity	-	-	-	-	-	-	1	0.6004	0.6995	-0.0105	-0.1829	0.7663
TDS	-	-	-	-	-	-	-	1	0.8303	0.0244	-0.217	0.6962
Chloride	-	-	-	-	-	-	-	-	1	-0.0542	-0.1942	0.7026
Nitrate	-	-	-	-	-	-	-	-	-	1	0.1746	-0.0651
Phosphate	-	-	-	-	-	-	-	-	-	-	1	-0.0889
Sulphate	-	-	-	-	-	-	-	-	-	-	-	1

in monsoon season, 2018 (Table 1). In general all large water bodies which were free from industrial pollutions *i.e.* Bada Madar, Chhota Madar, Fatehsagar and Udaisagar maintained high range of pH. Industrial pollution caused by zinc smelter and other industries was found responsible for comparatively low pH in pond of Berach river *viz*., Upstream, Downstream, Gadwa, Daroli pond as well as Sarjana tank of Vallabhnagar. Water pH was found high during monsoon period and low during summer period in large unpolluted water bodies. As mentioned earlier, pH range observed (6.4 to 9.1) was wide as compared to reports of other workers[50] observed pH of Pichhola (7.7–8.7) and Fatehsagar lake (7.4–9.2) respectively. As a result of industrial pollution pH range was acidic to alkaline in Berach river ponds in contrary to above mentioned alkaline ranges. During study pH of water was found to positive correlation with these parameters like nitrates, phosphates, dissolved oxygen and alkalinity (Table 3). Whereas relationships were negative found with total dissolved solids, sulphates, chlorides, electrical conductivity and hardness. However, above mentioned relationship were not significant as revealed from values of correlation coefficient depicted in Table 3.

3.4 Dissolved Oxygen

It is a vital chemical parameter affecting survival of aquatic organisms. Oxygen deficiency in ponds is known to cause mortality of aquatic organisms and fishes. Further it affects availability and solubility of various nutrients and therefore the productivity of aquatic ecosystems[51]. Dissolved oxygen has a unique correlation with temperature, free carbon dioxide and total alkalinity. These relationships make it more important and valuable parameter. Under the one atmospheric pressure, atmospheric oxygen solubility in freshwater ranges from 14.6 mg/l at 0 °C to 7 mg/l at 35 °C. The cold water has a greater capacity for holding dissolved oxygen as compare to normal water[52]. The dissolved oxygen has inverse correlation with total alkalinity[53]. Comparison of dissolved oxygen values in nine water bodies studied during different seasons revealed that minimum value was 3.8 mg/l and 8.9 mg/l maximum level of dissolved oxygen on the basis of the average values depicted in table 2 water of Daroli pond was found to hold minimum dissolved oxygen (3.73 mg/l). Although this value was based on only four observations made during winter and monsoon as the pond got dried during summer seasons of both the years. Another industrially polluted pond *i.e.* Gadwa pond located before Daroli pond in the Berach river bed was also poor in dissolved oxygen with an average value of 5.11 mg/l. Fatehsagar lake maintained rich dissolved oxygen throughout study period with an average value of 7.00 mg/l. Season wise values of dissolved oxygen (Table 1) show highest values (8.9 and 8.6 mg/l) in Bada Madar tank and Fatehsagar lake during winters of 2018 and 2019 respectively. Lowest values (3.8 and 4.6 mg/l) of dissolved oxygen were observed during winter 2018 and summer 2019 in Down-stream pond and Gadwa pond respectively. Thus it is clear that out of all nine water bodies studied; all large water bodies which were free from pollution had rich dissolved oxygen. Polluted ponds were characterized by low values of dissolved oxygen. During study dissolved oxygen tends to show positive correlation with pH, depth of visibility, total alkalinity and nitrates (Table 1). Whereas dissolved oxygen show negative correlation with phosphates, TDS, chlorides, sulphates, hardness, electrical conductivity and water temperature.

3.5 Total Alkalinity

Alkalinity is a measurement of the capacity of water to absorb hydrogen ions. It can also be described as a capacity to neutralize a strong acid and characterized by the presence of hydroxyl ions which combine with hydrogen ions. This is seemed total of carbonate and bicarbonate alkalinity[54]. Studied that alkalinity in itself is not harmful to human beings; still water with less than 100mg/l alkalinity is desirable for domestic use. During present investigation, a large difference in value of total alkalinity was observed between industrially polluted waters and unpolluted or domestically polluted water bodies (Table 1) on the basis of average values depicted in Table 2; Upstream pond was characterized with highest alkalinity of 285.5 mg/l and lowest alkalinity (101.83 mg/l) was shown by Daroli pond. Season-wise total alkalinity values (Table 1) indicated that Udaisagar lake had highest value of 324.00 mg/l during winter 2018 and lowest value of 68 mg/l was observed in Down-stream pond during winter of 2019 respectively. Maximum average total alkalinity was found in Up-stream pond (285.5mg/l) and minimum in Daroli pond (101.83 mg/l). As shown in the Table 3; total alkalinity showed positive relationship with electrical conductivity, nitrates, TDS, chlorides, dissolved

oxygen and pH. Its relationship was negative found with hardness, sulphates, phosphate and depth of visibility.

3.6 Hardness

Oligotrophic water bodies which are free from any contamination have soft water whereas meso-trophic and eutrophic water bodies contain hard water of calcium and magnesium due to solutes received by them. Hardness of water is mainly due to cations and anions like carbonates, bicarbonates and sulphates. As depicted in Table 2; highest average value of hardness (1059.47 mg/l) was noted in Gadwa pond whereas Chhota Madar tank had lowest value of 136.61 mg/l. High hardness values of Gadwa pond may be attributed to pollutants as well as intensive amount of lime added in effluent treatment plant which comes in the pond through effluent stream. Season and year-wise observation depicted in Table 1 indicate that during 2018 and 2019 maximum hardness values were 1794 and 1586 ppm in monsoon, 2018 and summer season, 2019 noted in Down-stream pond and Gadwa pond respectively. Water of Chhota Madar tank was soft during summer season of 2018 and 2019 as shown by lowest values of 128 and 70 ppm respectively. As shown in Table 3, hardness of water was found positively relationship with TDS, chlorides, electrical conductivity and sulphates. A negative relationship of hardness found with nitrates, phosphates, total alkalinity, dissolved oxygen, pH and depth of visibility.

3.7 Electrical Conductivity

Conductivity of water depends upon the presence of salts in the form of anions and cations. It is a rapid method to measure, total solids in water as it is directly related with total dissolved solids[55]. Conductivity is a good index to measure trophic status of water body oligotrophic waters are characterized by poor electrical conductivity which shows less numbers of free ions responsible for limiting effect on productivity. During study electrical conductivity was high in polluted water bodies (Tables 1 and 3). Metallic salts present in effluent were also responsible to enhance conductance values fluctuated between 0.12 and 4.482 m.mhos (Table 1). Highest mean conductivity (3.1018 m.mhos.) value was observed in Down-stream pond and a lowest mean conductivity (0.3178 m.mhos.) value was observed in Chhota Madar tank (Table 2). Table 1 depicting season wise and year wise values of physicochemical parameters revealed that during monsoon of 2018, maximum value (4.482 m.mhos.) was noted in Down-stream pond. Whereas during summer period of 2019, Gadwa pond showed highest value (3.46 m.mhos.) and lowest values of (0.12 and 0.114 m.mhos.) conductivity were noted during summer and monsoon periods of 2018 and 2019 respectively in Bada Madar tank. A close positive relationship of electrical conductivity with TDS, Sulphates, hardness, chlorides was noted (Table 3) during study. This was having negative correlation with depth of visibility, pH, DO, phosphates and nitrates.

3.8 Total Dissolved Solids

Total dissolved solids in a water body is a sum of dissolved salts viz sulphates, phosphates, carbonates, bicarbonates, chlorides, nitrates of calcium, sodium, potassium, iron and magnesium etc. The industrial and urban wastes disposed in water bodies are rich in these salts. Further, mineral based industries may discharge heavy metal and their salts. A high content of dissolved solids elevates the density of water and influences osmoregulation of freshwater organisms[55]. Water with high dissolved solids is an inferior portability and may induce unfavorable physiological responses of the body of consumer. Present observations include highest TDS value observed during winter 2018 (4999.2 ppm) in Down-stream pond and lowest value in Chhota Madar pond (146.4 ppm) observed during summer 2019 (Table 1). Comparison of mean value of TDS (Table 2) revealed that these were most rich (3488.03 ppm) in Down-stream pond and most poor in Chhota Madar pond (206.80 ppm). Downstream pond, which was a shallow pond receiving effluent from zinc smelter, had highest content of TDS during season of 2018 as well as 2019. Whereas lowest value of TDS (151.8 ppm) was observed from Bada Madar tank during monsoon period of 2018. In the next year (2019) this lowest value (146.4 ppm) was observed in summer from Chhota Madar tank. In the water of uncontaminated large water bodies viz Bada Madar tank, Chhota Madar tank, Fatehsagar lake TDS values were less than 500 ppm. Urban and industrial pollution in Udaisagar and in ponds of Berach river bed was responsible for high TDS values reaching up to 3488.03 ppm (Table 2). During study, strong positive correlation (Table 3) of TDS was noted with, hardness, conductivity, sulphates and chlorides.

Relationship was negative found with depth of visibility, pH and dissolved oxygen. Ranu[56] and Meena S[41] also observed strong positive relationship between TDS and electrical conductance, total alkalinity, pH and hardness of water.

3.9 Chlorides

Chloride content in water may indicate the level of pollution. Authors in[44,57,58] studied that domestic and industrial pollutants tend to increase chloride content of receiving water bodies. During present investigation also, it was noted that mean value of chlorides was highest (563.33 mg/l) in polluted Down-stream pond and lowest mean value of 66.83 ppm was observed in Fatehsagar lake which is free from any industrial pollution (Table 2). Season wise pattern further revealed that during both the years, Down-stream pond was loaded with rich chlorides, but in 2018 maximum content were found during monsoon season and in 2019 contents were highest in summer season. During the study Fatehsagar lake had lowest chloride value in monsoon, 2018 (62 mg/l) and winter, 2019 (51 mg/l) (Table 1). During study chlorides show significantly positive correlation with TDS, conductivity, hardness and sulphates[56]. Ranu[56] also observed similar relationship in water of Bandi river system.

3.10 Nitrates

Nitrate is the highest oxidized form of nitrogen and play an important role in the process of eutrophication and these are enriched by domestic sewage and agricultural runoff coming from catchment area of the lake. The concentration of nitrates in drinking water is toxic[59]. During study nitrate value ranged from 0.121 to 1.02 mg/l (Table 1). The minimum values of 0.121 mg/l were recorded in Bada Madar tank and Fatehsagar lake during winter 2018 and summer 2019 respectively. Lake Udaisagar was found to be enriched by maximum nitrates (1.02 mg/l) during summer 2018. As depicted in Table 1 no clear seasonal trend was observed in respect of nitrates variation, however in general these were high in water during summer season as compared to monsoon. Comparison of average values of nitrates (Table 2) showed that these were rich in Udaisagar (0.5645 mg/l) and poor in Daroli pond (0.2530 mg/l).

3.11 Phosphates

Phosphates are essential nutrients and also contribute in the process of eutrophication when these are present in excessive concentration. Whereas moderate presence of this nutrient maintain the water bodies suitable for growth of plankton and other fresh water communities. Season wise observations (Table 1) revealed that maximum value of phosphates (1.2401 mg/l) was in Chhota Madar tank during monsoon season of 2019. On the other hand lowest value (0.02 mg/l) was observed in Sarajana tank during summer 2018. On the basis of average values of total study period (Table 2), Chhota Madar tank was found to be most rich in phosphates (0.4856 mg/l) and Sarjana tank, Vallabhnagar was most poor in phosphates (0.0533 mg/l). Table 3 shows correlation coefficient between different physicochemical parameters which indicate positive relationship of phosphates with, nitrates and pH, whereas negative relationship was noted with dissolved oxygen, chlorides, electrical conductivity, TDS, total alkalinity and hardness.

3.12 Sulphates

Sulphates are invariably present in all water bodies. Water bodies located in arid and semiarid zones of Rajasthan are rich in sulphates[56]. Domestic and industrial effluents are also responsible for enrichment of sulphates in receiving water bodies. Mineral based industries which are either involved in processing of sulphur containing ores or using different forms of sulphur during processing may dispose considerable amount of sulphates. Out of nine water bodies studied during present investigation, industrially polluted ponds of Berach river were found to contain very high sulphates content. The average values (Table 2) clearly indicated maximum value of sulphates (1610.333 mg/l) in Down-stream pond and minimum value (20.167 mg/l) in Fateh sagar lake. Maximum values of sulphates were reported during monsoon period of 2019 in Down-stream pond. Sulphates were found to have strongly positive relationship with hardness, electrical conductivity, chlorides and TDS (Table 3). Negative relationship of these parameters was observed with dissolved oxygen, phosphates, total alkalinity, nitrates and depth of visibility.

4. Conclusions

India's water consumption has risen dramatically as a result of population, agricultural and industrial expansion. Turbidity, which is caused by suspended particles and planktonic organisms, reduces light penetration in water bodies. By increasing turbidity, domestic and industrial pollutants tend to reduce visibility depth. The concentration of suspended and dissolved impurities was caused by heavy evaporation of water during the summer. During different seasons of study, all nine water bodies studied maintained a slightly acidic to alkaline pH with average values ranging from 4.48 to 8.5 (Table 2). During study period of 2018–19, Daroli pond had the lowest pH (6.4) in monsoon, 2018, while lake Fatehsagar had the highest pH (9.1) in monsoon, 2019. Industrial pollution from zinc smelters and other industries was found to be the cause of low pH in Berach river ponds and Vallabhnagar's Sarjana tank. Cations and anions such as carbonates, bicarbonates and sulphates are the main causes of water hardness. The presence of salts in the form of anions and cations affects the conductivity of water. During study, metallic salts present in effluent were responsible for increasing conductance values between 0.12 to 4.482 m.mhos (Table 1). Total dissolved solids in a water body are the sum of dissolved salts such as sulphates, phosphates, carbonates, bicarbonates, chlorides, calcium, nitrates, sodium, potassium, iron and magnesium among others. These salts are abundant in industrial and urban wastes disposed in water bodies. TDS had a strong positive correlation (Table 3) with hardness, conductivity, sulphates and chlorides during study. The depth of visibility, pH and dissolved oxygen all had a negative relationship. TDS, conductivity, hardness and sulphates all had a significant positive correlation with chlorides. Table 3 shows the correlation coefficient between various physicochemical parameters, indicating that phosphates have a positive relationship with nitrates and pH, whereas dissolved oxygen, chlorides, electrical conductivity, total alkalinity and hardness have a negative relationship. Sulphate enrichment in water bodies is also caused by domestic and industrial effluents. Hardness, electrical conductivity, chlorides and TDS were all found to have a strong positive relationship with sulphates (Table 3). Dissolved oxygen, phosphates, total alkalinity, nitrates and visibility depth all had a negative relationship with these parameters.

5. References

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