International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2022): 7.942

Assessment of Surface and Ground Water Quality for Irrigation Purposes of a Subtropical Wetland in South West Coast of India

Dr. Jisha T. S.

Assistant Professor, Department of Chemistry, MSTM Arts and Science College, Perinthalmanna, Malappuram, Kerala, India
Corresponding Author Email: *jishanidheesh[at]gmail.com*

Abstract: ***This research work attempted to show some steps of the evaluation of surface and ground water in Kottuli wetland region, Kerala, India for irrigation purpose. It was noticed that the ground water samples collected in the nearby areas of Kallayi & Korappuzha estuaries and cannoli canal were not suitable for irrigation purpose. Wilcox diagram indicated that the majority of surface and groundwater of Kottuli wetland is good for irrigation purposes. Sodium hazard and salinity hazard is low for surface water samples while little high in few ground water samples from USSL diagram. The results obtained from this research make it possible to evaluate the suitability of surface water for irrigation and to draw useful recommendations for the policy makers and farmers.***

Keywords: Irrigation, surface water, USSL diagram, water quality

1. Introduction

Surface water is an important resource that can create tensions between different countries sharing the same water sources to know that the agriculture is considered as the last sector that exploits less water compared to the industry which uses very large water quantities. The future strategies of agricultural development in the most of these countries depend on the ability to maintain, improve and expand irrigated agriculture. Water in agricultural activities is an important component that is supplied by a network of irrigation channels. Rivers, lakes, and spring water are sources of irrigation water that are facing pollution problems. Agricultural water sources may be of poor quality because of natural causes, contamination, or both [1]. Indonesian rivers are polluted due to the discharge of untreated sewage and industrial effluents. The poor water quality of rivers and spring water has an effect on irrigation water quality. In the last century, surface water resources have been polluted to such levels that they could no longer be used in agricultural irrigation [2]. The quality of irrigation water directly influences the quality of the soil and the crops grown on this soil. Poor irrigation water quality has a negative effect on crop productivity, crop product quality, and public health of consumers and the farmers who come in direct contact with the irrigation water [3], [4], [5]. Problems originating Ffrom irrigation water quality can be categorized into four groups: (1) salinity hazards, (2) infiltration and permeability problems, (3) specific ion toxicity, and (4) miscellaneous problems [2]. Irrigation is an effective way to improve productivity significantly. However, there are environmental risks associated with irrigation, especially water stagnation and increased salinity. Agricultural irrigation is a factor of increase and diversification of crops. Surface water is impacted by natural and human influences, both of which are known to have a detrimental impact on water quality. Natural processes include precipitation, weathering, sediment movement, and dust deposition in the atmosphere [6], whereas human - induced processes include urban growth, agricultural and farming operations, and industrial and municipal wastes. These processes often degrade the water quality, and the physical and environmental integrity of aquatic life [7] - [8]. Urban run - offs and contaminated water from residential and industrial sources harm rivers and streams, causing eutrophication and trace metal inputs [9] - 10]. Uncontrolled release of polluted water into aquatic environments degrades water quality, making surface water unsuitable for drinking and irrigation uses [11]. However, poor irrigation water quality affects agricultural crop productivity and negatively impacts the health of local residents. The effect of water quality is assessed by the subsequent impact of the irrigation water on soil properties and agricultural crops [12] – [14]. Thus, monitoring irrigation water quality is imperative in enhancing ecological and human health states [15]. This is why its development must be encouraged in the world through agricultural, international, national and community policies [16]. For this reason, that successive governments have so far sought to harden the right to water while protecting the interests of irrigators. This strategy, if explained by the social contract that binds the state to farmers, is nonetheless debatable. The priority is no longer today to increase yields among the highest in the world, but to ensure the continuity of drinking water supply services, the preservation of aquatic ecosystems and sufficient water levels to respond industrial needs.

2. Materials and methods

2.1 Study area

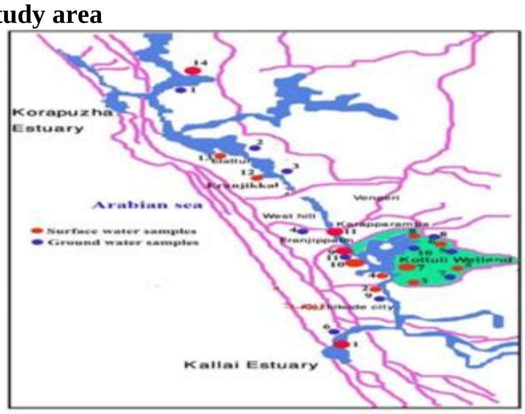

Figure 1: Study area and location of the Kottuli wetland

Kottuli wetland is the largest eco - patch in the Kozhikode city limits. It is interlinked with the man - made Canoly canal which receives tidal influx from the Kallai and Korapuzha estuaries. The portion of the wetland, now intact, is mainly on the eastern periphery of the Eranhipalam - Arayedathupalam stretch of Canoly Canal (11^0 19'25.9" N & 75^0 50' 24.3" E and 11^0 14'18.1" N & 75^0 47'43.6" E). It is a major receptacle of flood water from the city, a primary recharge source for wells in the vicinity, sink for pollutants including city and hospital waste and a rich mangrove habitat. Kottuli wetland directly or indirectly influence the health, economy, and social set up of Calicut city However, in recent years, the canal has degenerated to an urban sewer, stagnant with municipal and other filth. The rich floral biodiversity of 250 floral species including unique mangroves and its rare water birds [17] (Aziz et al.2009) also highly enriches tourism potential of the Kottuli wetlands. Originally, a part of this wetland with an area of about 87.04 hectares, of this, 22.5 hectares of land has been reclaimed for human settlement and the reclamation is continuing. Since Kottuli wetland located in the urban area of Kozhikkode, the industrial and domestic discharges in the adjacent areas have made unauthorized connection to the sewers to empty their untreated wastewater. The sewers on the other hand empty the water into the channels that later on join the wetlands. This is causing a deposition of the nutrients & heavy metals in the canals and ultimately led to the deterioration in the water quality of wetlands. Thus, due to different levels of anthropogenic pressures /activities like urban development, encroachment, discharge of domestic sewage, pesticides fertilizers and industrial effluents, infestation with aquatic weeds and eutrophication, disturbances from excessive recreational activities and tourism, and diversion of irrigation water, domestic use or industrial uses, this wetland has been under threat from various directions and hence, learning to explicate them is inevitable. The wetland at Kottuli is one among the 94 wetlands of national importance identified by the Government of India for conservation action under National Wetland Conservation Programme [18] (MoEF, 2006 - 2007).

2.2. Sampling and analysis of water quality parameters

To study the surface and ground water irrigational quality of Kottuli wetland, 14 surface water samples and 11 ground water samples were collected and analyzed for different chemical parameters. The surface water samples were collected during pre - monsoon, monsoon and post monsoon period of year 2022 - 2023 from the ponded area of Kottuli lake near Sarovaram tourism area and nearby areas on the stretch of Cannoli canal for the present study. The groundwater samples were collected adjacent to the surface water stations in the month of October 2023. All the water samples (i. e. surface and ground water) were collected in one - liter narrow mouthed pre - washed polyethylene bottles. The pH, electrical conductivity and Water quality parameters such as temperature, pH and DO were measured insitu. Preservation of samples and estimation of various water quality parameters were done as per standard procedures reported in [19] APHA (APHA 2009). The sampling stations were marked in the area map, figure 1.

3. Results and Discussion

3.1 Characterization of physicochemical parameters

The seasonal variation of major ion concentration of surface & ground water samples of Kottuli wetland system is demonstrated in table 1, 2, 3& 4 respectively.

Table 1: Seasonal variation of surface water quality data of Kottuli wetland (pre - monsoon)

Seasons	Stations	pH	TDSmg/l	Calcium mg/l	Magnesium mg/l	Sodium mg/l	Potassium mg/l	Chloride mg/l	Alkalinitymg/l	Nitrate - N mg/l	DO mg/l	BOD mg/l	Sulphate mg/l	phosphate – P mg/l
PRE - MONSOON	KTS1	5.8	73.75	28.80	2.91	13.60	2.20	24.00	20.00	12.67	ND	50.16	16.84	0.044
	KTS2	6.6	102.5	20.80	17.49	23.20	3.40	32.00	20.00	6.96	5.808	11.35	15.00	0.0383
	KTS3	6.30	82.14	27.20	1.944	13.60	2.60	28.00	24.00	8.32	ND	65.34	21.64	0.049
	KTS4	5.70	73.66	16.00	1.94	13.20	3.10	32.00	36.00	14.5	7.52	5.742	17.72	0.026
	KTS5	4.70	55.25	12.80	3.88	13.20	3.00	16.00	16.00	10.82	ND	29.7	18.68	0.041
	KTS6	6.30	68.13	16.00	3.88	18.80	2.80	20.00	16.00	8.7	9.76	6.20	21.04	0.02
	KTS7	6.90	79.86	19.20	10.69	15.06	2.50	24.00	12.00	13.75	8.646	6.01	19.04	0.030
	KTS8	6.60	83.42	32.00	5.83	18.00	3.10	24.00	12.00	5.2	4.68	1.52	17.72	0.043
	KTS9	8.00	85.93	35.20	1.94	18.40	2.40	20.00	8.00	4.9	8.31	5.14	18.40	0.044
	KTS10	6.00	75.78	25.60	0.97	15.60	2.60	28.00	12.00	10.75	8.58	6.20	18.44	0.034
	KTS11	6.40	63.2	22.40	1.94	16.80	2.50	12.00	16.00	6.86	5.87	3.96	18.88	0.032
	KTS12	5.9	91.58	28.80	17.49	14.40	1.70	16.00	16.00	9.72	10.09	6.79	22.64	0.035
	KTS13	6.7	84.68	28.80	7.77	25.20	2.20	16.00	16.00	4.25	10.75	7.59	17.36	0.043
	KTS14	6.3	77.73	25.60	18.46	20.40	1.20	8.00	16.00	3.55	9.504	7.656	17.80	0.036

Paper ID: SR24602193427 DOI: https://dx.doi.org/10.21275/SR24602193427

Table 2: Seasonal variation of surface water quality data of Kottuli wetland (monsoon)

Seasons	Stations	pH	TDSmg/l	Calcium mg/l	Magnesium mg/l	Sodium mg/l	Potassium mg/l	Chloride mg/I	Alkalinitymg/l	Nitrate - N mg/l	DO mg/l	BOD mg/l	Sulphate mg/l	phosphate - P mg/l
- MONSOON	KTS1	6.40	62.37	11.20	9.72	6.00	1.00	8.00	12.00	8.60	ND	73.26	14.32	0.86
	KTS2	7.50	84.58	19.20	11.66	17.2	1.6	20.00	16.00	12.60	8.81	5.80	11.38	0.76
	KTS3	5.90	75.52	20.80	1.94	11.20	1.40	12.00	16.00	17.80	ND	77.22	17.32	0.76
	KTS4	6.20	58.43	9.60	1.94	10.00	1.30	12.00	24.00	13.20	10.82	8.316	15.36	0.45
	KTS5	5.18	50.34	8.00	4.86	10.40	1.80	4.00	16.00	11.30	ND	37.62	15.04	0.76
	KTS6	6.50	61.34	6.40	7.77	14.00	1.40	8.00	8.00	16.67	10.63	5.80	16.16	0.46
	KTS7	7.40	62.73	8.00	9.72	10.80	1.00	12.00	4.00	7.65	9.9	5.80	15.36	0.56
	KTS8	7.80	80.88	25.60	4.86	12.00	1.60	12.00	8.00	8.83	7.59	3.762	13.00	0.75
	KTS9	7.80	71.23	22.40	4.86	13.60	0.70	8.00	12.00	14.6	9.57	5.35	13.60	0.76
	KTS10	6.40	70.23	20.80	1.94	11.60	1.10	12.00	16.00	11.34	10.76	7.19	14.36	0.55
	KTS11	7.50	56.33	16.00	0	10.40	1.10	8.00	16.00	13.62	7.656	5.28	15.12	0.65
	KTS12	6.60	81.58	24.00	11.66	10.40	0.8	12.00	12.00	5.50	12.41	7.59	17.44	0.52
	KTS13	6.80	74.5	22.40	8.74	18.40	1.4	8.00	16.00	7.40	11.15	7.46	13.92	0.61
	KTS14	6.80	68.90	19.20	13.60	16.00	0.5	8.00	8.00	16.12	10.03	5.12	14.56	0.55

Table 3: Seasonal variation of surface water quality data of Kottuli wetland (post - monsoon)

Seasons	Stations	pH	TDSmg/l	Calcium mg/l	Magnesium mg/l	Sodium mg/l	Potassium mg/l	Chloride mg/I	Alkalinitymg/l	Nitrate - N mg/l	DO mg/l	BOD mg/l	Sulphate mg/l	phosphate - P mg/l
POST - MONSOON	KTS1	7.90	32.67	1.60	2.91	9.20	1.40	16.00	4.00	12.42	ND	55.44	6.88	0.054
	KTS2	8.04	66.12	16.00	2.92	13.60	2.70	24.00	4.00	13.30	6.79	4.68	8.60	0.04
	KTS3	6.40	56.99	12.80	3.88	8.00	2.00	24.00	12.00	20.35	ND	73.26	12.92	0.05
	KTS4	7.75	49.12	4.80	4.86	7.20	2.30	20.00	8.00	15.8	9.76	7.65	7.48	0.03
	KTS5	5.60	40.4	4.80	4.86	6.00	2.00	12.00	8.00	14.2	ND	33.66	8.20	0.05
	KTS6	7.08	47.41	3.20	5.83	11.20	1.80	16.00	4.00	19.25	10.03	5.47	11.28	0.03
	KTS7	8.00	48.1	4.80	2.91	8.00	1.80	16.00	8.00	11.34	9.50	5.74	8.00	0.046
	KTS8	8.11	64.93	14.40	9.72	9.60	2.30	20.00	4.00	13.28	5.74	2.17	7.48	0.056
	KTS9	8.21	60.98	16.00	5.83	10.40	1.80	12.00	4.00	16.7	9.04	5.41	7.00	0.054
	KTS10	7.21	53.78	11.20	4.86	10.00	1.60	20.00	8.00	14.41	10.23	7.12	7.28	0.042
	KTS11	8.01	47.31	3.20	6.80	7.20	1.80	12.00	4.00	16.58	6.40	4.42	7.76	0.040
	KTS12	7.50	70.8	17.60	10.69	6.00	1.50	16.00	8.00	9.37	10.62	8.38	12.96	0.046
	KTS13	7.20	56.6	12.80	4.86	15.20	1.80	12.00	8.00	10.26	11.28	7.78	7.84	0.05
	KTS14	7.21	57.64	11.20	7.77	11.60	0.90	8.00	8.00	16.12	10.82	6.60	6.12	0.043

Table 4: Ground water quality data of Kottuli wetland

Stations	pH	EC, micro siemens/cm	TDS, mg/l	Cal cium mg/l	Magnesium mg/l	Sodium mg/l	Potassium mg/l	Chloride mg/I	Alkalinity mg/l	Nitrate - N mg/l	Sulphate mg/l	Inorganic phosphate - P mg/l
KTG1	6.80	2778.00	1777.92	96.00	77.76	248.00	23.00	617.60	591.00	16.00	760.00	0.064
KTG2	6.44	93.80	60.032	3.20	2.91	14.40	1.50	30.88	31.52	10.30	10.40	0.023
KTG3	5.20	35.55	22.75	1.60	1.94	6.00	0.80	7.72	11.82	11.60	5.60	0.014
KTG4	5.59	42.32	27.084	1.60	0.97	3.60	2.40	7.72	7.88	5.27	13.20	0.032
KTG5	4.72	80.08	51.25	1.60	1.94	10.40	1.80	19.30	19.70	8.14	20.80	0.001
KTG6	4.45	1752.60	1121.66	64.00	29.16	212.00	16.00	501.80	394.00	16.5	320.00	0.056
KTG7	6.65	65.05	41.63	1.60	0.97	5.60	3.20	7.72	7.88	6.54	26.00	0.029
KTG8	6.90	66.48	42.54	1.60	3.88	13.20	4.30	7.72	11.82	6.36	14.40	0.026
KTG9	5.73	1079.00	690.56	3.20	4.86	224.00	3.30	308.80	236.40	11.60	160.00	0.043
KTG10	6.48	244.04	156.18	1.60	1.94	10.00	6.20	115.80	11.82	7.20	20.80	0.032
KTG11	6.72	40.08	25.65	1.60	0.97	8.80	4.50	3.86	11.82	12.40	6.40	0.027

3.2. Suitability for irrigation use of Kottuli wetland

Water for irrigation, to maintain sustainable agriculture, should satisfy the needs of soil and the crop as the liquid phase in soil water plant growth and crop production. Irrigation water quality is depending upon both the type and the quantity of the dissolved salts originates from natural and anthropological sources. Irrigation status of Kottuli wetland, both surface & ground water based on sodium percent (%Na), Sodium adsorption ratio (SAR) Magnesium ratio (MR) and residual sodium carbonate (RSC) are presented in Table 3.

3.2.1 Sodium Percent (% Na)

Sodium concentration is important in classifying irrigation water because excess of sodium concentration in water replaces calcium and magnesium ions in the soil leads to deterioration of the soil properties and reduces soil permeability [20] (Kelly 1951). In all - natural waters, sodium percentage Na % is the most important parameter in determining the suitability of water foirrigation use [21] (Wilcox 1948). Elevated level of sodium percent causes deflocculation and impairment of the tilth and permeability of soils [22] (Karanth 1987) and may produce harmful levels of exchangeable sodium in most soils that will require special soil management like good drainage, high leaching, and organic matter additions. The Na% can be estimated by the following equation [23] (Todd 1980):

$$Na\% = Na+K/\ (Ca+Mg+Na+K)\ X\ 100,$$

where all the ions are expressed in meq/l

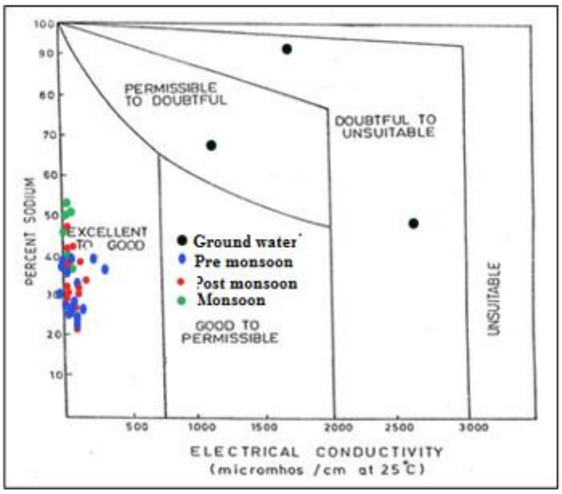

Figure 2: Wilcox diagram for classification of surface and ground water samples of Kottuli wetland based on EC and Na%

Wilcox classified surface & groundwater for irrigation purposes based on per cent sodium and electrical conductivity. Sodium percentage calculated in the study area is plotted against electrical conductance in Wilcox diagram (Figure 2). According to which percent sodium in surface water samples of Kottuli wetland in all seasons, i. e., in pre - monsoon ranges from 21 to 50 meq/l, in post monsoon ranges from 12.29 to 37.94 meq/l, in monsoon season it ranges from 18.65 to 43.45 meq/l and ground water samples of Kottuli wetland ranges from 50.25 to 94.56 meq/l as mentioned in Table 5 (a) & (b). & Figure 2. All surface water samples of Kottuli wetland fall in excellent to good water class indicating that water is fit for irrigation and also majority of ground water samples fall in excellent to good water class, but it was also noticed that one ground water sample lies under permissible to doubtful category and two samples were in doubtful to unsuitable category. This indicates that the majority of surface and ground water of Kottuli wetland is good for irrigation purposes.

3.2.2. Sodium Adsorption Ratio (SAR)

The process of cation exchange reaction in soil which is expressed in terms of ratio is known as sodium adsorption ratio (SAR). Todd 1980 [23] describes that SAR is an important parameter for the determination of the suitability of irrigation water because it is responsible for the sodium hazard. SAR value of irrigation water quantifies the relative proportions of sodium (Na^+) to calcium (Ca^{2+}) and magnesium (Mg^{2+}) and is a measure of alkali/sodium hazard to crop. The SAR values in the study area can be calculated by the following equation given by [24] (Hem 1991) as:

It is expressed as: Sodium Adsorption Ratio (SAR) = $Na^+ / \sqrt{Ca^{2+} + Mg^{2+} / 2}$ (All the values are expressed in epm) The SAR values for all samples are mentioned in Table 3. Based upon these values, Figure 3 [25] (USSL.1954) indicates that in all seasons, surface water samples fall in S1 - C1 class whereas majority of ground water samples fall in S1 – C1 class except three samples, two in S4 - C3 & one in S4 - C4 class in Kottuli wetland which indicates that sodium hazard and salinity hazard is low for surface water samples while little high in few ground water samples.

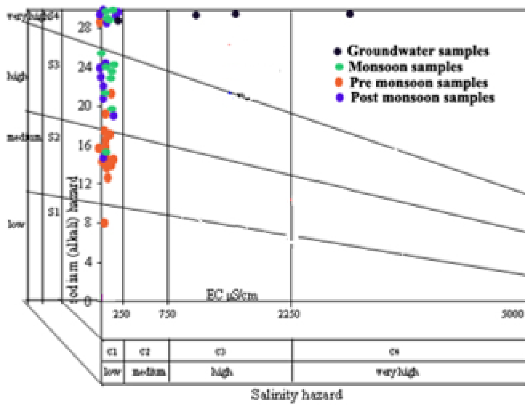

Figure 3: USSL classification of surface and ground water samples of Kottuli wetland

3.2.3 Residual Sodium Carbonate (RSC)

[26] Eaton 1980 recommended the concentration of residual sodium carbonate to determine the suitability of water for irrigation purposes. Residual Sodium Carbonate is used to find the suitability of water for irrigation purpose and helps to indicate the alkalinity hazard in the soil. The water having excess of carbonate and bicarbonate may lead to calcium and magnesium carbonate precipitation in the soil as water is concentrated by evapo - transpiration. This results into the increase of sodium proportionate which exerts same adverse effect as high amount of sodium in irrigation water. In irrigation water having high concentration of $HCO3^–$, there is a tendency for Ca^{2+} and Mg^{2+} to precipitate as $CO_3^{2–}$. The effect of $CO_3^{2–}$ and $HCO3^{–}$ ion on quality of water was expressed in terms of the Residual Sodium Carbonate (RSC) [26] (Eaton 1950). The sum of carbonate and bicarbonate in water over the sum of calcium and magnesium influences the

Paper ID: SR24602193427 DOI: https://dx.doi.org/10.21275/SR24602193427

suitability of water for irrigation [27], [28], [29] (Brindha et al.2011, Joshi et al.2009 and Raju et al.2009). This is termed as residual sodium carbonate (RSC). Residual sodium carbonate.

(RSC) is calculated as follows [30] (Ragunath 1987):

Residual Sodium Carbonate (RSC) = (CO_3^{2-} + HCO^{3-}) – (Ca^{2+} + Mg^2)

If RSC < 1.25 meq/l the water falls in safe category, if RSC lies between 1.25 – 2.5 meq/l then water marginally suitable and if RSC > 2.5 meq/l the water is unsuitable for irrigation.

High value of residual sodium carbonate (RSC) in water value leads to an increase in the adsorption of sodium on soil [26] (Eaton 1950) and also causes the soil structure to deteriorate, as it restricts the water and air movement through soil. Table 5 (a) & (b). shows that in Kottuli wetland during pre, post & monsoon seasons all surface water samples falls in safe category and all groundwater samples falls in safe category except one (RSC.3.31) is unsuitable for irrigation. This indicates that surface and ground water of Kottuli wetland is suitable for irrigation purpose.

3.2.4. Magnesium Ratio (MR)

Magnesium ratio (MR) is generally described as the high amount of magnesium over the calcium. Normally calcium and magnesium are in the condition of equilibrium [27], [31] (Brindha et al.2011, Pandian et al.2016). If magnesium is in excess amount, it leads to adverse effects on the soils which results into poor crop yield. According to Szabolcs et al 1964 [32] magnesium hazard (MH) value for irrigation water is calculated by the following equation:

Magnesium Ratio (MR) = Mg^{2+} / Ca^{2+} + Mg^{2+} × 100 (All the values are expressed in epm)

The value of magnesium ratio greater than 50 percent is considered as suitable for irrigation purposes [33], [34]. [35] (Palliwal 1972, Sreedevi 2004 and Tripathi et al.2012). In Kottuli wetland, magnesium ratio of pre - monsoon samples varies from 9.72 to 81.64 meq/l, post monsoon samples vary from 41 to 80.57 meq/l and in groundwater samples it varies from 44.84 to 87.68 meq/l as mentioned in Table 5 (a) & (b). The study reveals that out of total 53 samples (including pre - monsoon, monsoon, post monsoon and ground water) the magnesium ratio of 27 samples is higher than 50 percent which indicate it is suitable for irrigation and 26 samples are unsuitable for irrigation as magnesium ratio is less than 50 percent in Kottuli wetland.

3.2.5. Corrosivity Ratio (CR)

Corrosivity ratio (CR) helps to know whether water can be transported in the metallic pipes or not [36] (Mahadevaswamy et al.2001). It describes the susceptibility of water to corrosion and is expressed as ratio of alkaline earths to saline salts in water [31] (Pandian et al.2007). The corrosivity ratio is calculated by the formula:

Corrosivity Ratio *(*CR) = (Cl^- / 35.5) + 2 (SO_4^- / 96) / 2 (HCO_3^- + CO_3^{2-}/100*)* (All the values are expressed in epm)

The water with corrosivity ratio less than one is considered to be safe for transport of water in any pipes [37], [31] (Balasumbramanian 1986, Pandian et al.2007) and if the corrosivity ratio is more than one, only non - corrosive pipes such as Polyvinyl Chloride (PVC) pipes should be used. In Kottuli wetland, all the water samples (i. e. pre - monsoon, post monsoon, monsoon) and ground water have corrosivity ratio less than one (safe zone) as mentioned in Table 5 (a) & (b).

Table.5 (a): Values of different irrigation parameters (meq/l) in Kottuli wetland (KT1 to KT8)

Sample No.	SAR				%Na				RSC				MR				CR			
	post	pre	mon	ground	post	pre	mon	ground	post	pre	mon	ground	post	pre	mon	ground	post	pre	mon	ground
KT1	0.57	0.65	0.59	3.36	27.15	47.01	24.99	50.20	- 1.49	0.01	- 1.3	- 1.59	14.44	75.23	59.12	57.45	0.01	0.02	0.01	0.51
KT2	1.02	0.79	0.69	0.63	30.14	43.06	25.99	62.25	- 2.24	- 0.72	- 1.87	0.11	58.37	23.30	50.31	60.30	0.01	0.03	0.02	0.02
KT3	0.98	0.62	0.55	0.49	29.69	35.17	25.64	53.76	- 1.26	- 0.57	- 1.01	- 0.05	10.64	33.61	13.48	66.94	0.01	0.02	0.02	0.006
KT4	0.80	0.49	0.40	0.40	39.68	42.05	37.94	57.52	- 0.57	- 0.05	- 0.51	- 0.03	16.84	62.79	25.23	50.31	0.01	0.03	0.02	0.006
KT5	0.80	0.49	0.45	0.49	39.34	43.59	29.56	67.32	- 0.70	- 0.38	- 0.67	0.08	33.61	62.79	50.31	66.94	0.03	0.01	0.01	0.01
KT6	0.80	0.53	0.49	2.37	43.45	49.95	36.60	63.10	- 0.99	- 0.38	- 0.9	0.83	28.83	75.23	66.94	43.16	0.06	0.02	0.01	0.40
KT7	0.69	0.68	0.55	0.40	28.13	50.62	25.40	66.90	- 1.65	- 0.29	- 1.08	- 0.03	48.14	50.31	66.94	50.31	0.01	0.02	0.01	0.006
KT8	1.24	0.72	0.65	0.64	28.75	26.89	22.77	62.87	- 1.95	- 1.33	- 1.62	- 0.21	23.3	52.94	24.04	80.20	0.01	0.02	0.02	0.006

Table.5 (b): Values of different irrigation parameters (meq/l) in Kottuli wetland (KT9 to KT14)

Sample No.	SAR				%Na				RSC			MR				CR				
	post	pre	mon	ground	post	pre	mon	ground	post	pre	mon	ground	post	pre	mon	ground	post	pre	mon	ground
KT9	1.13	0.69	0.62	0.75	30.57	32.15	25.2	94.56	- 1.86	- 1.15	- 1.46	3.31	8.429	37.79	26.56	71.68	0.01	0.02	0.01	0.24
KT10	0.98	0.58	0.55	0.49	34.58	35.56	29.44	71.04	- 1.23	- 0.77	- 1.07	- 0.05	5.952	41.97	13.48	66.94	0.01	0.02	0.02	0.09
KT11	0.85	0.57	0.45	0.40	37.72	39.79	32.04	75.56	- 1.09	- 0.46	- 0.73	0.03	12.64	77.99	0	50.31	0.01	0.01	0.01	0.003
KT12	1.33	0.85	0.74		18.65	21.07	12.29		- 2.64	- 1.51	- 2.04		50.31	50.31	44.75		0.01	0.01	0.01	
KT13	1.02	0.72	0.68		35.35	44.44	27.95		- 1.89	- 0.78	- 1.72		31.03	38.76	39.43		0.01	0.01	0.01	
KT14	1.10	0.84	0.72		24.4	36.97	20.35		- 2.56	- 0.95	- 1.96		54.59	53.64	54.15		0.01	0.01	0.01	

4. Conclusion

Irrigation status of Kottuli wetland was evaluated based on sodium percent (%Na), Sodium adsorption ratio (SAR) Magnesium ratio (MR) and residual sodium carbonate (RSC). All the surface water samples in Kottuli wetland fall in the suitable range for irrigation purpose either from SAR, % Na or RSC, M. H. R values in all seasons, but it was noticed that the ground water samples collected in the nearby areas of Kallayi, Korappuzha estuaries and cannoli canal were not suitable for irrigation purpose. Wilcox diagram indicated that sodium hazard and salinity hazard is low for surface water samples while little high in few ground water samples. Sodium hazard and salinity hazard is low for surface water samples while little high in few ground water samples from USSL diagram. Based on corrosivity ratio (CR), all the analysed water samples was preventive of corrosion of pipes.

References

[1] R. S. Ayers, D. W. Westcot "Water Quality for Agriculture, FAO Irrigation and Drainage", Paper No. (29), Rev. (1), U. N. Food and Agriculture Organitation, Rome, 1985.

[2] C. Simsek, O. Gunduz, "IWQ Index: A GIS - Integrated Technique to Assess Irrigation Water Quality", Journal of Environmental Monitoring and Assessment, 128: 277 - 300, 2007

[3] M. Qadir, D. Wichelns, L. Raschid - Sally, P. S. Minhas, P. Drechsel, A. Bahri, and P. McCornich, "Agricultural Use of Marginal - Quality Water Opportunities and Challenges", IWMI Part 4: 225 - 226, 2007.

[4] V. D. Listkas, V. G. Aschonitis, and V. Z. Antonopulos, "Water Quality in irrigation and Drainage Networks of Thessalonski Plain in Greece Related to Land Use, Water Management, and Agroecosystem Protection", Environ. Monit. Assess.163: 347 - 359 264, 2010.

[5] M. N. Muthanna, "Quality Assessment of Tigris River by Using Water Quality Index for Irrigation Purpose", European Journal of Scientific Research, 57: 15 - 28, 2011.

[6] A. R. M. Towfiqul Islam, S. Shen, M. Bodrud - Doza, M. Safiur Rahman, "Assessing irrigation water quality in Faridpur district of Bangladesh using several indices and statistical approaches", Arab. J. Geosci., 10, 418, 2017, [CrossRef]

[7] N. Ouali, B. E. Belabed, H. . Chenchouni, "Modelling environment contamination with heavy metals in flathead grey mullet Mugil cephalus and upper sediments from north African coasts of the Mediterranean Sea", Sci. Total Environ., 639, 156–174, 2018, [CrossRef]

[8] A. R. M. T. Islam, H. M. T. Islam, M. U. Mia, R. Khan, M. A. Habib, M. Bodrud - Doza, M. A. B. Siddique, R. Chu, "Co - distribution, possible origins, status and potential health risk of trace elements in surface water sources from six major river basins, Bangladesh", Chemosphere, 249, 126180, 2020 [CrossRef]

[9] M. Bodrud - Doza, A. R. M. T. Islam, F. Ahmed, S. Das, N. Saha, M. S. Rahman "Characterization of groundwater quality using water evaluation indices, multivariate statistics and geostatistics in central Bangladesh". Water Sci., 30, 19–40, 2016. [CrossRef]

[10] M. A. B. Siddique, A. R. M. T. Islam, M. S. Hossain, R. Khan, M. A. Akbor, M Hasanuzzaman, M. W. M. Sajid, M. Y. Mia, J. Mallick, M. S. Rahman,. "Multivariate statistics and entropy theory for irrigation water quality and entropy - weighted index development in a subtropical urban river, Bangladesh", Environ. Sci. Pollut. Res., 29, 8577–8596, 2021. [CrossRef] [PubMed]

[11] A. Merouche, S. Selvam, Y. Imessaoudene, C. N. Maten, "Assessment of dam water quality for irrigation in the northeast of catchment Cheliff - Zahrez, Central Algeria", Environ. Dev. Sustain., 22, 5709–5730, 2020. [CrossRef]

[12] S. Etteieb, S. Cherif, J. Tarhouni, "Hydrochemical assessment of water quality for irrigation: A case study of the Medjerda River in Tunisia", Appl. Water Sci., 7, 469–480, 2017. [CrossRef]

[13] A. A. Soltani, A. Bermad, H. Boutaghane, A. Oukil, O. Abdalla, M. Hasbaia, R. Oulebsir, S. Zeroual, A. Lefkir, "An integrated approach for assessing surface water quality: Case of Beni Haroun dam (Northeast Algeria) " Environ. Monit. Assess.192, 630, 2020. [CrossRef]

[14] T. Airi, L. Belkhiri, L. Mouni, "Evaluation of surface water quality for drinking purposes using fuzzy inference system", Groundwater for Sustainable Development, 6: 235 - 244, 2018.

[15] USEPA (United States Environmental Protection Agency). Risk Assessment Guidance for Superfund. Human Health Evaluation Manual (Part A). EPA/540/1 - 89/002 Office of Emergency and Remedial Response. Volume 1. Washington, DC: U. S. Environmental Protection Agency; 1989

[16] L. Belkhiri, L. Mouni, A. Tiri, T. S. Narany, R. Nouibet, "Spatial analysis of groundwater quality using self - organizing maps", Groundwater for Sustainable Development., 7: 121 - 132, 2018.

[17] P. A. Azeez, Rachna Chandra, P. R. Nikhil Raj, "Conservation of Kottuli wetlands. Technical Report", DOI: 10.13140/RG.2.1.3133.3284, 2008.

[18] MoEF (2006 - 2007). Annual Report. Annexure VI A & VI B. pp 273 - 276

[19] A. P. H. A. (2009). Standard methods for the examination of water and waste water 21st Ed. American Public Health Association Washington. DC.

[20] W. P. Kelly, "Alkali soils - their formation properties and reclamation", 3rd edition, Reinhold Publication, New York, USA, 92 p, 1951.

[21] L. V. Wilcox, "Classification and use of irrigation waters", US Department of Agriculture, Arc 969, Washington DC, 28p, 1955.

[22] K. K. Karanth, "Ground water assessment, development and management" Tata McGraw - Hill Education, 720p, 1987.

[23] D. K. Todd, "Groundwater hydrology", 3rd Edn., Wiley and Sons Inc., New York, U. S., 625p, 1995.

[24] J. D. Hem, "Study and Interpretation of the Chemical Characteristics of Natural Water", Scientific Publishers, 1991.

[25] U. S. Salinity Laboratory Staff 1954. Diagnosis and Improvement of Saline and Alkali Soils, U. S. Dept. Agriculture Hand Book, 160p

[26] F. M. Eaton, "Significance of carbonates in irrigation waters", Soil. Sci., v.69, pp.123 - 133, 1950.

[27] K. Brindha,, L. Elanko, "Impact of Tanning Industries on Groundwater Quality near a Metropolitan City in India" Water Resour Manage, 26, pp.1747 - 1756, 2012.
[28] D. M. Joshi, A. Kumar, N. Agrawal, "Assessment of the irrigation water quality of River Ganga in Haridwar district India", J. Chem., v.2 (2), pp.285 - 292, 2009.
[29] N. J. Raju, P. Ram, S. Dey, "Groundwater quality in the lower Varuna river basin, Varanasi district, Uttar Pradesh", J. Geol. Soc. India, 73p.178, 2009.
[30] I. M. Raghunath, "Groundwater", 2nd Edn., Wiley Eastern Ltd., New Delhi, India, 1987.
[31] R. Ramesh Pandian, M. C. Sashikkumar, S. Selvam, "Appraisal of irrigation water quality study in coastal aquifers of Tuticorin city, Tamilnadu, India", Indian Journal of Geo Marine Sciences, 45 (11), pp.1522 - 1530, 2016.
[32] I. Szabolcs, C. Darab, "The Influence of Irrigation Water of High Sodium Carbonate Content of Soils", Proceedings of 8th International Congress of ISSS, 2, 803 - 812, 1964.
[33] K. V. Paliwal, "Irrigation with Saline Water. Water Technology Centre, Indian Agriculture Research Institute, New Delhi, 198 p, 1972.
[34] Sreedevi, P. D. (2004) Groundwater Quality of Pageru River Basin, Cuddapah District, Andhra Pradesh", Journal of Geological Society of India, 64, 619 - 636.
[35] Prakash Tripadhi, K. V. Lavande, V. Sankar, "Influence of micro - irrigation methods on growth, storage & yield of Rabi onion", Indian Journal of Horticulture,.61 - 65, 2010.
[36] G. Mahadevaswamy, D. Nagaraju, S. Siddalingamurthy, Lakshmamma, M. Mohammad Subhanlone,, P. C. Nagesh, K. Rao, "Groundwater quality studies in Nanjangud Taluk, Mysore Dist., Karnataka, India", Int. J. Environ. Sci., 1 (7): 1582 - 1591, 2011.
[37] A. Balasubramanian, "Hydrogeological investigations of Tambraparni River Basin, Tamil Nadu", Ph. D thesis submitted to University of Mysore, 1986.

Author Profile

Jisha. T. S, received the B Sc Chemistry and M Sc Chemistry from Calicut university, Kerala and Avinashilingam university, Tamilnadu, respectively. During 2007 - 20012, she has been working as Junior Research Fellow in Centre for Water Resources Development and Management (CWRDM), Calicut. She currently working as assistant professor in the Department of Chemistry, MSTM Arts and Science College, Perinthalmanna, Kerala. Did her Ph. D in Chemistry from Kannur university, Kerala in 2018. Currently she working as assistant professor in Department of Chemistry, MSTM Arts and Science college, Perinthalmanna, Malappuram, Kerala.