Impact of domestic and industrial effluent discharge on the tank ecosystem in Pallipattu block, Tamil Nadu, India

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The impact of untreated effluent from dye industries and domestic sewage that are discharged into the irrigation tank in Pandravedu village in South India was assessed through physico-chemical analysis of water samples and focus group discussion with the community. Thirty-six samples were collected from the study area across three seasons and analysed in the laboratory. The irrigation water quality indices computed indicated that the levels of sodium, salinity and hardness exceeded the permissible limits of irrigation standards. Consequently, rice yield had reduced by 40% in the region, thereby affecting the livelihood of the farmers. The colour of fishes in the tank also changed and their consumption contributed to health-related issues in the village.

Keywords: Domestic sewage, integrated effluent, irrigation tanks, water quality.

IN recent times, irrigation tanks have become receptacles for domestic sewage and industrial effluent. Dubey *et al.*[1] reported that 70% of surface water is polluted and Indian textile industries contribute 15–20% of the industrial effluent. The disposal of this effluent into tanks has an adverse effect on the soil, health of the flora, fauna, human beings and livestock. This also causes depletion of dissolved oxygen due to eutrophication and the death of fishes in the tanks. Also due to depleting groundwater levels, the aquifer gets contaminated when wastewater is stored in irrigation tanks over longer periods.

In India, although wetlands like tanks provide multiple services, their management has received inadequate attention in the national water sector agenda. One such tank is Pandravedu, located in Pallipattu block, Tamil Nadu (TN), South India. The Pothatturpettai village known for its dyeing units, has neither effluent treatment plants nor sewage treatment plants. The untreated wastewater is let into the Pandravedu tank through a lined channel, leading to deterioration of both surface water and groundwater of Pandravedu village and the entire tank ecosystem. Hence the present study was undertaken to assess the impact on the tank ecosystem while discharging effluents from dyeing industries and domestic wastewater into an irrigation tank. The specific objectives were to assess (a) the water quality for irrigation and fisheries, and (b) ascertain the impact of wastewater discharge on the Pandravedu tank ecosystem.

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Study area

Pandravedu tank selected for the present study, is the last of a four non-system tank cascade. Around nine villages are benefited from this cascade. It falls in the Nagari watershed in Thiruvallur district, TN. Figure 1 shows the Pandravedu tank and sampling locations.

The area is generally hilly with hard rock formations overlain by top sandy soil up to a depth of 1.5–3 m, followed by highly weathered formation of granite and granitic gneisses up to 7.5 m. While the average annual rainfall of the study area is 895 mm, it experienced rainfall of 11.9 cm during November 2014, which is below the corresponding monthly average rainfall of 18.2 cm. Pandravedu tank is located amidst mountains and receives supply from four channels – two from Pandravedu hill, one from Jangallipalli hill and another one is the surplus weir from Pothatturpettai tank. The surplus water from Pandravedu tank goes into Chitteri tank and from there it flows to Periamedupalli. It then joins Kosasthalaiyar river and feeds into Poondi reservoir. There are about 1000 small and medium farmers who are benefited by this tank for multiple purposes. The main occupations in these villages are farming, livestock-rearing and fishing. The farmers in the area cultivate paddy during *kharif* and *rabi* seasons, and vegetables like onion and chilli during summer. In addition to agriculture, most of the villagers largely depend on non-farming activities like weaving and dyeing. There are about 150 dyeing units in Pothatturpettai village, only half of the dyeing industries has obtained licence for its establishment. Until 1996, weaving was done in Pothatturpettai and dyeing was done in Kanchipuram, which is known for silk sarees and handloom industry. From 1997, people started dyeing in their own units in Pothatturpettai, and the untreated effluent

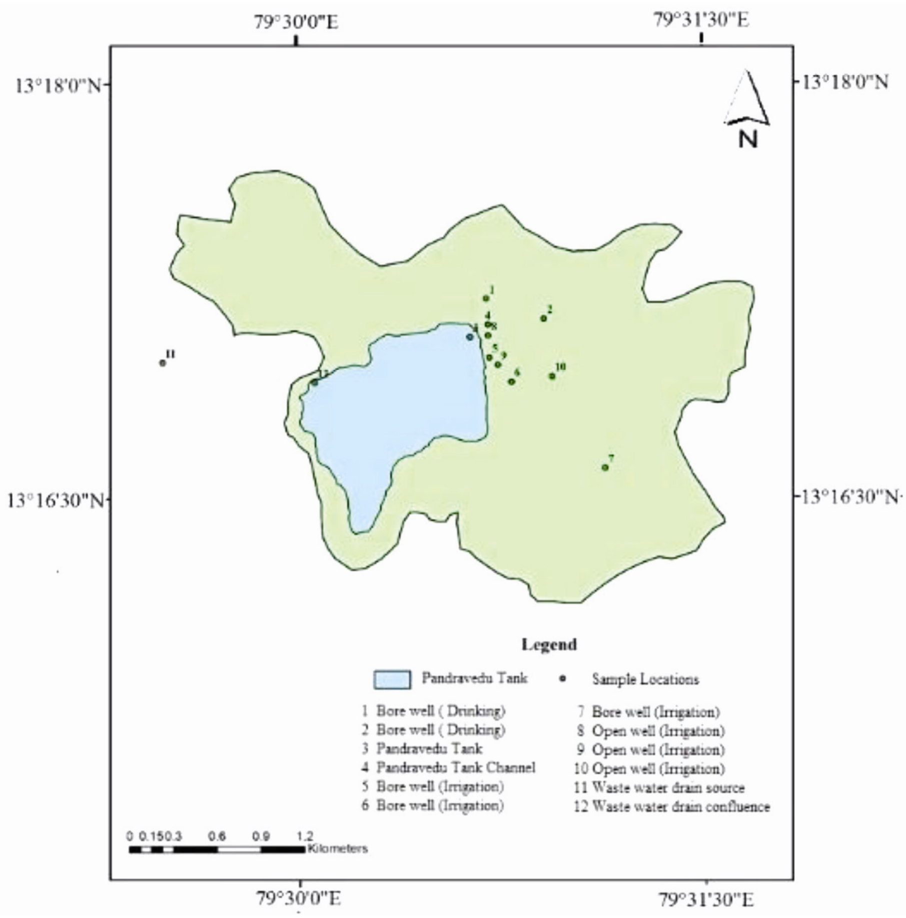

Figure 1. Village map showing the tank and sample locations in Pandravedu village, Tamil Nadu, India.

from these dyeing units was let into a barren land in Pothatturpettai village. Since it posed health issues, a lined channel of 2 km length was constructed to discharge the untreated effluent from the dyeing units to a nearby tank (called Thamaraikullam). From there, effluent water is being discharged into a small pond called Thangal, which is close to Pandravedu tank. The wastewater that runs through the channel is dark brown in colour and has a bad odour.

Methodology

To understand the water quality variations, 36 water samples, 12 in each season (indicated as 1–12 in Figure 1), were collected in clean plastic cans during pre-monsoon (May 2014), monsoon (November 2014) and post-monsoon (January 2015). All the samples collected were analysed in the laboratory for physico-chemical parameters like total dissolved solids (TDS), electrical conductivity (EC), total hardness (TH), total alkalinity (TA), pH, calcium, magnesium, sodium, potassium, chloride, nitrate, sulphate, biochemical oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen (DO), iron, copper, zinc, chromium using standard procedures recommended by the American Public Health Association[2]. The analytical results of wastewater samples were compared with maximum tolerance limits according to Indian standards[3]. The irrigation water quality indices, namely sodium adsorption ratio (SAR), percentage sodium (%Na), residual sodium bicarbonate (RSBC) and Kelly's ratio (KR) were computed and compared with the standards. Wilcox diagram was plotted using Aquachem software to assess the sodium and salinity hazard. Focused group discussions with farmers and the public, including landless labourers were conducted to gather community perceptions on changing water quality and its implication on economic, ecological and socio-cultural functions.

Results and discussion

Characterization of wastewater

To understand the polluting source, characterization of wastewater was done by collecting samples during premonsoon, monsoon and post-monsoon seasons from

Table 1. Comparison of wastewater characteristics with maximum tolerance limit across three seasons

Parameters	Maximum tolerance limits (mg/l)	Pre-monsoon		Monsoon		Post-monsoon	
		11*	12*	11*	12*	11*	12*
pH	5.5–9.0	7.53	6.92	7.52	7.23	7.79	8.1
Free ammonia	5	5.69	4.31	5.08	0.13	2.19	5.02
BOD	30	160	140	19	2	40	54
COD	250	356	342	52.1	8	104	194
Chromium	2	0.019	0.026	0.002	0	0.003	0.008
Copper	3	0.00424	0.00351	0.00281	0	0.00187	0.00881
Zinc	5	0.429	0.365	0.11	0.042	0.323	0.527

11*, Sampling location at origin of wastewater drain.
12*, Sampling location at confluence of wastewater drain.

Figure 2. Wastewater from dyeing units flowing through the drains.

two locations, namely wastewater discharge point and confluence point. The collected samples are then analysed in the laboratory. Table 1 shows the results of the analysis of water samples and maximum tolerance limits for industrial effluent discharged into surface water bodies like river, lake, pond and irrigation tank according to standards[3].

The results indicate that pH values are within the limits during all the three seasons. Free ammonia tested at the origin of the wastewater drain exceeded the maximum tolerance limit during pre-monsoon and monsoon seasons, while at confluence point it exceeded the limit in post-monsoon season. BOD values exceeded the maximum tolerance limit of 30 mg/l during the pre-monsoon and post-monsoon seasons, whereas during monsoon season these values were within the limits. COD values showed that during pre-monsoon season both the samples exceeded the maximum tolerance limit of 250 mg/l, while during monsoon and post-monsoon seasons, the values were within the range. Similarly, heavy metals like chromium, copper and zinc were within the maximum tolerance limit. All the above-mentioned parameters were higher at the confluence point than at the origin, due to the discharge of untreated dye industry wastewater from a nearby factory, in addition to wastewater from the drain. Dyeing industries use water from their own borewells or that supplied by the town panchayat. On an average, a typical small-scale dyeing unit consumes 100–150 litres of water/day.

Figure 2 shows the source point of the drain carrying wastewater from the dyeing units and the confluence point where a private dye industry is letting its untreated wastewater into the channel. Thus continuous wastewater flow into the tank has resulted in exceedance of maximum tolerance limit of free ammonia, BOD and COD according to standards[3], thereby polluting the Pandravedu tank ecosystem and the nearby aquifer.

Evaluation of irrigation water quality

Farmers depend both on surface water and groundwater for agriculture, livestock and fisheries. Generally, in this region, the irrigation tanks dry up during summer season (March–May) and hence irrigation is supplemented with groundwater. However, in the recent past, due to continuous inflow of wastewater into the tank, there is stagnation of water to almost its full capacity. Despite the increase in availability of water throughout the year, its effect on both the surface water and groundwater quality is not appreciated by the people. The same was attributed by the farmers and landless agricultural labourers based on their observation that the quality of surface water and groundwater is deteriorating. This has paved way for an in-depth analysis of water quality and its effect on the farming system and tank ecosystem. To accomplish this, irrigation indices were computed, as discussed in the subsequent sections. Table 2 compares the irrigation indices of water samples from sample locations 3–12 for pre-monsoon, monsoon and post-monsoon seasons.

Table 2. Irrigation indices for pre-monsoon, monsoon and post-monsoon seasons

Parameters	Season	3	4	5	6	7	8	9	10	11	12
pH	Pre-monsoon	8.2	8.3	7	8.2	6.6	7.9	8.1	7.4	7.5	6.9
	Monsoon	8.1	8.2	7.4	7.3	7.2	7.1	7.3	7.3	7.5	7.2
	Post-monsoon	8.2	8.2	7.6	7	6.8	6.9	7.2	7	7.8	8.1
EC (μmho/cm)	Pre-monsoon	1619	1435	1705	1441	1549	1449	1490	1281	2019	1987
	Monsoon	1640	1610	1557	1051	3270	1476	1038	1724	1738	1643
	Post-monsoon	2140	2210	1641	1608	3080	1912	1716	1793	1526	6240
TDS (mg/l)	Pre-monsoon	1133	1005	1194	1009	1084	1014	1043	897	1413	1391
	Monsoon	1148	1127	1090	736	2289	1033	727	1207	1217	1150
	Post-monsoon	1498	1547	1149	1126	2156	1338	1201	1255	1068	4368
TH (mg/l)	Pre-monsoon	304	292	560	280	480	288	316	312	712	640
	Monsoon	232	228	408	224	800	556	232	412	404	472
	Post-monsoon	510	500	444	472	1120	452	352	488	384	1100
TA (mg/l)	Pre-monsoon	284	296	328	284	400	304	300	268	532	500
	Monsoon	200	216	284	208	408	324	208	304	484	488
	Post-monsoon	312	288	340	328	400	352	300	348	392	340
SAR	Pre-monsoon	5.7	4.7	2.1	4.6	2.4	4.6	4.6	3.4	2.6	2.4
	Monsoon	6.6	6.6	3	3.5	4.9	1.1	3.2	3.8	3.9	2.8
	Post-monsoon	4.4	4.6	3.1	2.9	2.3	4.5	4.1	3.2	3.3	10.3
% Na	Pre-monsoon	63	58.6	32.3	59.1	36.6	58.5	57.4	49.7	33.5	33.3
	Monsoon	68.8	69.4	43.6	54.6	47	20.5	52	48.8	50.2	39.9
	Post-monsoon	50.2	51.1	42	40.6	26.4	55.2	50.2	44	46.5	61.5
MAR	Pre-monsoon	32.8	34.2	31.3	32.8	31.4	32	36.8	33.4	22.9	22.8
	Monsoon	21.3	18.2	19.5	22.2	19.8	38.9	21.7	26.2	21.7	42.3
	Post-monsoon	23.7	40	30.9	37.2	30.5	33.2	21.3	34.9	17.5	31
KR	Pre-monsoon	1.6	1.4	0.5	1.4	0.6	1.4	1.3	1	0.5	0.5
	Monsoon	2.1	2.2	0.8	1.2	0.9	0.2	1.1	0.9	1	0.6
	Post-monsoon	1	1	0.7	0.7	0.4	1.2	1	0.8	0.8	1.6
RSBC (mg/l)	Pre-monsoon	0.6	1	–2.3	0.9	0	1.1	0.9	0.2	–2.2	–1.7
	Monsoon	–0.4	–0.2	–1.9	–0.1	–6.1	–1.5	–0.2	–1.1	1.6	2.6
	Post-monsoon	–2.7	–1.3	–1	–0.5	–9	0.2	–1.3	–0.2	–0.5	–9.4
PI	Pre-monsoon	75.5	73.7	45.3	74.3	53	74.1	71.5	65.9	46.5	47.1
	Monsoon	80.4	81.5	58.1	72.8	55	36.2	70.8	62.1	67.1	57.3
	Post-monsoon	60.6	61.2	55.8	54.7	34.2	68.7	62.8	58.3	62.7	65.1

Table 3. Comparison of electrical conductivity (EC) and total dissolved solids (TDS) for pre-monsoon, monsoon and post-monsoon seasons

			Sample representation (sampling locations in Figure 1)		
EC (μmho/cm)	TDS (mg/l)	Classification	Pre-monsoon	Monsoon	Post-monsoon
<250	<175	Class 1, excellent	Nil	Nil	Nil
250–750	175–525	Class 2, good	Nil	Nil	Nil
750–2000	525–1400	Class 3, permissible	3–10 and 12	3–6, 8–12	5, 6, 8–11
2000–3000	1400–2100	Class 4, doubtful	11	11	3 and 4
>3000	>2100	Class 5, unsuitable	Nil	7	7 and 12

Electrical conductivity and total dissolved solids

Salinity hazard to crops is measured using EC as it reflects TDS in groundwater. Water uptake by plant roots through osmotic process is limited by the presence of salts, which in turn hinder growth. Thus, higher EC values tend to reduce water availability in the root zone, thereby reducing transpiration and other metabolic activities. Table 3 shows the classification of irrigation water based on EC and TDS values for the three seasons. Doubtful and unsuitable class samples, namely 3, 4, 7, 11 and 12 are from the tank, tank channel, bore well at tail reach and wastewater drain source and confluence respectively. According to Fipps[4], the samples that fall in the

Table 4. Classification of irrigation water based on total hardness

TH (mg/l)	Classification	Sample representation (sampling locations in Figure 1) Pre-monsoon	Monsoon	Post-monsoon
<50	Soft	Nil	Nil	Nil
50–75	Moderately soft	Nil	Nil	Nil
75–150	Slightly hard	Nil	Nil	Nil
150–300	Hard	4, 6 and 8	3, 4, 6 and 9	Nil
>300	Very hard	3, 5, 7, 9–12	5, 7, 8, 10–12	3–12

Table 5. Classification of irrigation water based on sodium adsorption ratio (SAR)

SAR (mg/l)	Classification	Sample representation (sampling locations in Figure 1) Pre-monsoon	Monsoon	Post-monsoon
1–10	Low	All samples	All samples	3–11
10–18	Medium	–	–	12
18–26	High	–	–	–
>26	Very high	–	–	–

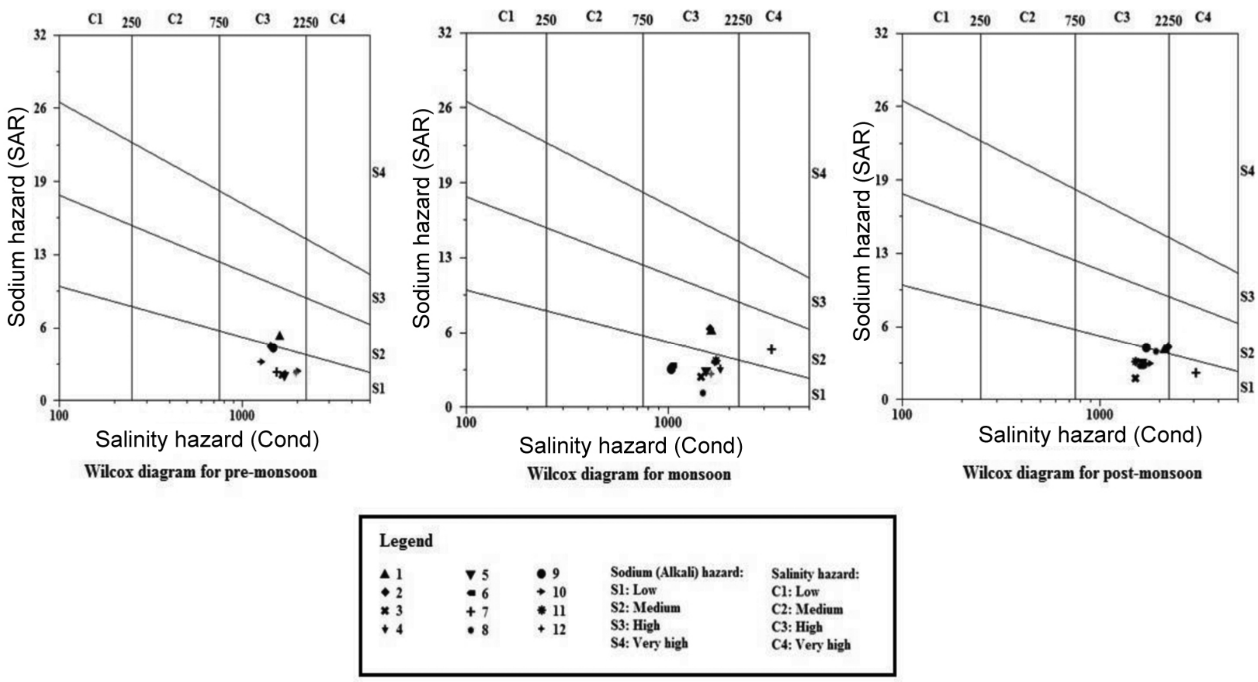

Figure 3. Wilcox diagram for various monsoon seasons.

permissible class need leaching and those that fall in doubtful and unsuitable class need good drainage without which the crops get damaged due to salinity, if grown, will have difficulty in obtaining stands. This water can be used to irrigate salt-tolerant and semi-tolerant crops under favourable drainage conditions.

Table 4 shows the classification of irrigation water based on TH, which indicates that during pre-monsoon and monsoon seasons, 70% and 60% of the samples fall in very hard category respectively, while during post-monsoon season all the samples fall in very hard category. The hardness of water results in scale formation in the pipe lines, which was observed during the water sample collection. The water quality analysis indicates that total alkalinity in the study area ranged between 268 and 532 mg/l during pre-monsoon season, while it ranged between 200 and 488 mg/l during monsoon season. However, during post-monsoon season, it ranged between 288 and 400 mg/l. The above results indicate that the tank water and open wells are unsuitable for irrigation across seasons.

Table 6. Classification of irrigation water based on % sodium

% Na	Classification	Sample representation (sampling locations in Figure 1) Pre-monsoon	Monsoon	Post-monsoon
<20	Excellent	Nil	Nil	Nil
20–40	Good	5, 7, 11 and 12	8, 11 and 12	7
40–60	Permissible	4, 6, 8–10	5–7, 9 and 10	3–6, 9–11
60–80	Doubtful	3	3 and 4	12
>80	Unsuitable	Nil	Nil	8

Table 7. Classification of irrigation water based on Kelly's ratio (KR)

KR	Classification	Sample representation (sampling locations in Figure 1) Pre-monsoon	Monsoon	Post-monsoon
<1	Suitable	5, 7, 10–12	5, 7, 8, 10–12	3, 5–7, 9–11
1–3	Excess sodium	3, 4, 6, 8 and 9	3, 4, 6 and 9	4, 8 and 12
>3	Unsuitable	Nil	Nil	Nil

Sodium adsorption ratio

SAR is a measure of sodium in the soil. It helps assess the hazard to crops due to sodium. SAR was calculated using eq. (1) given by Richards[5], as

$$\mathrm{SAR} = \frac{\mathrm{Na}^{+}}{\sqrt{\frac{\mathrm{Ca}^{2+} + \mathrm{Mg}^{2+}}{2}}}, \qquad (1)$$

where all the ions are expressed in meg/l.

Table 5 shows the classification of water based on sodium hazard. Computation of SAR indicates that all the samples fall in low sodium category, except sample 12, which is from wastewater drain confluence point. Though SAR values indicate that there is no anticipated sodium hazard to the crops, analytical data plotted on Willox diagram indicate that certain samples have high salinity and medium sodium hazard which is explained below.

According to Wilcox[6], water is classified into C1, C2, C3 and C4 categories based on salinity hazard and S1, S2, S3 and S4 categories based on sodium hazard. The Wilcox diagram (Figure 3) indicates that during pre-monsoon season the tank water falls in C4S2 and the rest of the samples fall in C3S1 category, whereas during monsoon season 17% of the samples fall in C3S2, 75% in C3S1 and the remaining 8% in C4S2, indicating high salinity and medium sodium hazard. During post-monsoon season, 40% of the samples fall in C3S2 which have high salinity and medium sodium hazard, 50% of the samples fall in C3S1 class that have high salinity and low sodium hazard, while 10% of samples fall in C4S1 class which have high salinity and low sodium hazard. The samples that fall in C3S2 class are from Pandravedu tank, its channel, open well 1 and open well 2. It is clear that open wells are also polluted due to the inlet of wastewater. Similarly, as mentioned earlier, the sample falling in C4S2 (monsoon season) is a borewell at tail end of the tank command area, which is also close to the mountains. Sodium- and saline-sensitive crops like rice, corn, lettuce, tomato and onion cannot be cultivated using this water, unless proper management and control measures are adopted. This scenario found in the Pandravedu tank and its command area is attributed due to the mixing of untreated dye industry wastewater and untreated sewage water.

Percentage sodium

The %Na was calculated according to the equation given by Todd[7] as follows

$$\%\mathrm{Na} = \frac{(\mathrm{Na}^{+} + \mathrm{K}^{+})}{(\mathrm{Ca}^{2+} + \mathrm{Mg}^{2+} + \mathrm{Na}^{2+} + \mathrm{K}^{+})} \times 100, \qquad (2)$$

where all the ions are expressed in meg/l. Table 6 shows the classification of water based on %Na and sample representation for pre-monsoon, monsoon and post-monsoon seasons. Samples 3, 4 and 12 that fall in the doubtful class are taken from tank, tank channel and wastewater at confluence point.

The water sample from borewell 8 falls in the unsuitable class. When the concentration of sodium is high in irrigation water, sodium ions tend to be absorbed by clay particles, displacing magnesium and calcium ions. This exchange of sodium in the water for calcium and magnesium in the soil reduces its permeability and results in soil with poor drainage. Thus, the circulation air and

Table 8. Comparison of tank water quality for pre-monsoon, monsoon and post-monsoon seasons with the permissible range for fisheries

Parameters	Acceptable range	Desirable range	Stress range	Pre-monsoon	Monsoon	Post-monsoon
pH	7–9.5	6.5–9	<4, >11	8.24	8.1	8.2
TH (mg/l)	>20	75–100	<20, >300	304	232	510
TA (mg/l)	50–200	25–100	<20, >300	284	200	312
Ca (mg/l)	4–160	25–100	<10, >250	82	74	156
Free NH_4 (mg/l)	–	–	–	0.23	0.92	2.8
NO_2 (mg/l)	0.02–2	<0.02	>0.2	0.04	0.04	0.07
NO_3 (mg/l)	0–100	0.1–4.5	>100, <0.01	5	21	21
DO (mg/l)	3–5	5	<5	3.2	5.5	3.5
BOD (mg/l)	3–6	1–2	>10	9	8	18

water is restricted during wet conditions and such soils are usually hard when dry[8].

Residual sodium bicarbonate carbonate

The suitability of water for irrigation purposes is influenced by the presence of carbonate and bicarbonate. RSBC was calculated using the equation given by Gupta and Gupta[9] as follows

$$\mathrm{RSBC} = \mathrm{HCO_3} - \mathrm{Ca^{2+}}, \tag{3}$$

where RSBC and the concentration of the constituents are expressed in meq/l. The RSBC values of water samples for pre-monsoon range between –2.3 and 1.1 mg/l, whereas during monsoon season they range between –6.11 and 2.6 mg/l, while during post-monsoon season they range between –9.4 and 0.2 mg/l. The negative RSBC values indicate that the dissolved calcium ions are more than the bicarbonate ions. The RSBC values were less than 5 for all the samples during the three seasons, and thus safe for irrigation.

Kelly's ratio

KR was calculated by measuring sodium against calcium and magnesium following the equation given by Kelly[10]

$$\mathrm{KR} = \frac{\mathrm{Na^+}}{\mathrm{Ca^{2+}} + \mathrm{Mg^{2+}}}, \tag{4}$$

where all the ions are expressed in meg/l.

Table 7 shows the classification of irrigation water based on KR values.

The samples that fall in the excess sodium class are tank, its channel, bore well, two open wells and wastewater at confluence point. Presence of excess sodium could be attributed to local contamination of domestic sewage[11]. In the present case, it is clear that the borewells and open wells near Pandrvedu tank command area have excess sodium, which is due to the inlet of untreated domestic sewage from the upstream village Pothatturpettai. This will further affect rice cultivation and the productive lands of Pandravedu.

Effects of irrigation water quality on agriculture

Cropping pattern in this village five years ago was paddy followed by chilli, groundnut, ragi and other dry crops depending on tank water availability. Due to the continuous inflow of wastewater into the tank, there has been shift in the cropping pattern with paddy followed by paddy and sugarcane. Even with paddy, there is a change from fine variety to a fat variety like ADT 37. The participants of the focus group discussion perceived that paddy cultivated from wastewater had an adverse impact on their health. Hence the paddy cultivated in the village is sold, while more expensive variety is purchased from open market. Stunted paddy growth reported by the farmers is attributed to the poor quality of water. Water quality analysis confirmed that high salinity and excess sodium lead to poor water quality in the command area. The conjunctive use of water prevails among the farmers as a coping strategy to dilute the poor surface water with groundwater. According to the farmers, the entire land is being affected by water pollution and due to this there is a reduction of paddy yield (ADT 37) to about 40%, which has a negative impact on family income. Poor, spotty stands of crops, uneven, stunted growth and poor yields are due to excess salinity[12].

Implications on livestock and fishing

Livestock and fishing play a vital role in the income of farmers and landless communities. Prior to the changing water quality scenario until 2005 in this village, people depended on tank water for livestock. Nowadays, animals fall sick and there is reduction in milk yield by around 20%. Also, instead of tank water, drinking water supplied for the people is used for livestock as well.

As a traditional fishing practice, the villagers collectively harvest fish during summer and consume the same.

Natural yield of fish was profuse in Pandravedu tank. Major varieties harvested were koravai (snake head), kelluthi (cat fish), kendai (carp) and veral (murrel). However, for the past five years, villagers could harvest only tilapia and no other species. Tilapia is the only variety that is tolerant to adverse environmental conditions[13]. Some of the villagers mentioned during the focus group discussion that the colour of the fish has also changed (Figure 4) and 40% of people who consumed them reported vomiting and diarrhoea. The villagers also mentioned that there was huge mortality of fishes; the same could be attributed to the depletion of DO in the water because of high organic loading from the untreated effluent and sewage water. These are clear indications of the negative implications of changing water quality on the farming systems.

Table 8 illustrates the water quality criteria for fisheries in tanks and ponds[14]. Water samples from the Pandravedu tank were tested during pre-monsoon, monsoon and post-monsoon seasons. The TA and TH values exceeded the desirable range, while calcium content was within the desirable range during all the seasons. Nitrite and nitrate contents in the tank exceeded the desirable range across seasons. DO value exceeded the desirable range during monsoon season. BOD content exceeded the desirable range during all the three seasons. Free ammonia that exists in the dissolved form in water is extremely toxic to fish.

Experiments have shown that the lethal concentration of ammonia for a variety of fish species ranges from 0.2 to 2.0 mg/l (ref. 15). The free ammonia tested in the Pandravedu tank shows that 0.23–2.8 mg/l levels are toxic to the fish species. Thus, from the above analysis it is clear that most of the parameters exceeded the desirable limits and this could be the reason for high fish mortality and poor quality of fishes. The effluent discharged caused severe impact on agriculture, fisheries and drinking water.

Figure 4. The dark colour of tilapia fish in the Pandravedu tank.

Changes in biodiversity of tank ecosystem

The Pandravedu tank once maintained a healthy ecosystem with good floral and faunal biodiversity. After the advent of small-scale dyeing industries, not only the water quality but also the rich biodiversity is declining. According to the farmers, they used to collect crabs from the tank area and paddy fields and consume them, especially during monsoon season. Nowadays there are no crabs in the tank area. The farmers also mentioned some of changes like disappearance of ponnagani (dwarf copperleaf) in floral biodiversity, which needs in-depth exploration.

During the focus group discussion, the participants expressed their concerns and the practices they have adopted to address the same.

Conclusion

It can concluded from the present study that the discharge of untreated wastewater from dyeing industries and untreated sewage water has deteriorated the tank water and groundwater quality in Pandravedu village. A comparison of irrigation indices clearly reveals that the tank water, bore wells, open wells and wastewater fall between hard and very hard category. EC and TDS of the wastewater at origin of drain fall in the doubtful class. The % Na results indicate that tank water sample falls in doubtful class and KR indicates that tank water, a bore well, an open well and wastewater sample at origin have excess sodium. Wilcox diagram illustrates that Pandravedu tank water has high salinity and medium sodium hazard. Sodium and saline-sensitive crops cannot be cultivated unless proper management and control measures are adopted. Focused group discussion revealed that in Pandravedu tank command area, there is reduction in paddy yield by about 40%. Based on earlier studies, reduction in the yield can be attributed to high salinity and sodium content in the water. The water is also not suitable for livestock. The cause for fish mortality and poor quality of fishes is due to exceedance of most of the parameters. The wastewater discharged through the drain when analysed shows that free ammonia, BOD and COD values are very high and exceed the maximum tolerance limit. Hence this study emphasizes the need for appropriate disposal measures for sewage and dye industry effluents in order to protect groundwater, human health, livestock and biodiversity of the tank ecosystem and ensure sustainable development.

Conflict of interest: The authors declare that they have no conflict of interest.

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