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CHARACTERISTICS OF THE WATER OF SHRIMP FARM AND ITS APPLICABILITY FOR IRRIGATION

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ABSTRACT

This research is an attempt to analysis the characteristics of water of shrimp farm to evaluate the suitability of this water for irrigation. In this case, three shrimp farms were chosen. They're all in Khulna. To analyze the wastewater characteristics, water quality parameters BOD, COD, pH, turbidity, color, conductivity, TS, TDS, TSS, TC, FC, DO, Cl^-, NO_3^-, SO_4^{2-}, Iron, Sodium, Calcium, Magnesium, SAR were tested in monthly intervals. Then the obtained results were compared to the ECR'97 (Environmental Conservation Rule 1997) standard value (for wastewater effluent). Because the values of most measures are within the standard limit, the features of the shrimp farms water were not particularly dissatisfactory though that of certain parameters such as COD (529.3~ 6213.21 mg/L), Conductivity (1993~7000 µm/cm), TDS (2740~10200 mg/L), TSS (190~2590 mg/L), Cl^- (624~5900 mg/L) exceed the Bangladesh standard value (ECR'97). These wastewater quality indicators were also compared to irrigation water appropriate values. The comparison was performed in a tabular format as well as graphical representation, taking into account the feasibility of repurposing shrimp farm water for irrigation. Due to the high salinity and SAR value of the shrimp farm water, it was determined that it could not be utilized directly.

Keywords: *Shrimp Farm water, SAR, Salinity, Irrigation, Suitability.*

1. INTRODUCTION

In Bangladesh's coastal districts, shrimp farming is one of the fastest expanding economic activity. Bangladesh is the world's fifth-largest shrimp producer. It accounts for more than 70% of overall agro-based product export revenues. Shrimp farming employs more than two million people, both directly and indirectly (Harvesting, Culture, Processing, and Exporting) (Rahman, 2017). Shrimps are mainly grown in two coastal locations in Bangladesh: the south-west coastal region, which includes the districts of Khulna, Bagerhat, and Satkhira, and the south-east coastal region, which includes the districts of Chittagong and Cox's Bazar. The main cultured species are tiger shrimp, commonly known as Bagda (technical name *Penaeus monodon*) and the Golda (technical name *Macrobrachium rosenbergii*). Bagda is a marine shrimp and is generally cultivated in coastal water having salinity higher than fresh water but not as much as sea water (Brackish water). The second one Golda is cultivated in the water having low salinity.

Since the 1970s, farmers have pushed shrimp cultivation due to significant worldwide market demand and high product prices. In the years 1980-1985, the Bangladesh government recognized shrimp farming as an industry and took the required steps to enhance shrimp output. (Haque, 1994).In 1979–80, slightly more than 20,000 ha were under shrimp cultivation (Ahmed, 1988). The entire area under

shrimp culture was predicted to expand from 96,048 hectares in 1990 to 135,000 ha in 2005, according to the Master Plan Organization (MPO 1986). There were around 130,000–138,000 ha of shrimp farms in 1994. (Rosenberry, 1995), exceeding the projection for 2005. According to one estimate, production in 2005 would be 89,000 t (Marr Associates 1985) as opposed to production of 30,000 t in 1995 (Rosenberry, 1995In Bangladesh's coastal region, shrimp culture has resulted in ecological imbalance, pollution, rising salinity, destruction of mangrove resources and other plants, biodiversity loss, and decreased land productivity (Alauddin and Hamid, 1998).

A huge amount of water is wasted in shrimp aquaculture activities. Irrigation with wastewater allows for the resolution of issues such as disposal, reuse, and water saving. With the increasing shortage of fresh water resources in many arid and semi-arid parts of the world, the use of municipal wastewater in agriculture is a centuries-old technique that is now garnering renewed attention. Around 20 million hectares of land are irrigated with wastewater globally (Scott *et al*. 2004). As water scarcity worsens and wastewater output rises, this is anticipated to increase dramatically over the next several decades. (Biswas, 2016).

Irrigation accounts for 70% of global water usage, including all water diverted from rivers and pumped from underground. As a result, the globe is experiencing a severe water deficit. According to a UN report, 2.7 billion people will face severe water shortages by 2025, requiring us to develop and execute new water management policies (Kretschmer, 2002).
Integrating aquaculture production into traditional agriculture may be one solution. Farming's impact on already scarce water resources, as well as its reliance on chemical fertilizers, may both be decreased, resulting in a higher economic return per unit of water. Effluents from land-based freshwater aquaculture may be used to produce a wide range of agricultural goods (McIntosh, 2002).

From this perspective, this study focuses on the properties of shrimp farm water and its suitability for irrigation, particularly in the Khulna region.

In undertaking this study, there were some specific objectives.The study aims at determining the physical and chemical quality of the water of shrimp farm to evaluate the quality of shrimp farm water by comparing with the wastewater of Bangladesh standard (ECR’97) and assess the suitability for reuse of the wastewater of shrimp farm in irrigation according to BIWQS (Bangladesh Irrigation Water Quality Standard).

2. METHODOLOGY

2.1 Selection of Shrimp Farms

Khulna lies between 22049' North latitude and 89034' East longitude. The majority of this area is low-lying ground that is only one meter above mean sea level and below high tide. As a result, during high tide, all of the lowlands are swamped, and tidal intrusion causes salinity. The districts of Khulna, Bagherhat, and Shatkhira account for almost 75% of all shrimp farms. Shrimp culture has a lot of promise in Khulna.
The location of the selected three shrimp farms are as follows:

1. Location 01: It is located in Aranghata, by the side of Khulna-Jashore bypass road. It lies between22052´24.6´´N latitude and 89029´30.3´´E longitude.

2. Location 02: It is located in the village named Deana, Daulatpur. It lies between 22051´35´´N latitude and 89030´32´´E longitude.
3. Location 03: It is located in Phultola village, Botiaghata, by the side of Rupsha River. It lies between 22042´43.5´´N latitude and 89031´31.7´´E longitude. The name of the farm is "Khan Fisheries".

2.2 Sample collection

The samples were collected from each selected shrimp farm at monthly intervals. 1.5-liter bottles were used for collecting the water of shrimp farm. The bottles were completely filled with water in a way so that no air remains above the surface. The opening of these bottles was closed tightly to prevent leakage of water. The bottles were kept in black coloured bag so that sun rays or day light could not reach to the samples.

2.3 Laboratory tests of wastewater quality parameters

The wastewater quality parameters of the collected samples were tested in the laboratory. The parameters were BOD5, COD, pH, Turbidity, Color, Conductivity, TS, TDS, TSS, TC, FC, DO, Chloride, Nitrate, Iron, Sulfate, Sodium, Calcium, Magnesium and for irrigation water quality index SAR. All the parameters were tested according to standard methods.

2.4 SAR Index

The sodium adsorption ratio (SAR) is a measure of the quality of irrigation water. It is a measure of a water's appropriateness for agricultural irrigation based on the concentrations of the primary alkaline and earth alkaline cations present in the water. SAR index of the shrimp farm water were determined by following relation:

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

After performing the laboratory tests, the obtained values were compared to Bangladesh standard value (ECR'97) for industrial effluent for the assessment of shrimp processing effluent. Then graphical presentation was performed. The obtained values were further compared to the Bangladesh standard (ECR'97) for irrigation water to find out whether the shrimp processing effluent was suitable for irrigation purpose or not.

3. RESULTS AND DISCUSSION

3.1 Water Quality of Shrimp Farm Water

The laboratory test results of wastewater from shrimp farms are shown in Table 1. The table shows that, some wastewater quality parameters are in the range of the standard values mentioned in the "Environmental Conservation Rule, 97". These parameters include BOD, COD, pH, Turbidity, TC, FC, DO, Nitrate, Iron, Sulfate etc. Some of the values of Conductivity (2780, 1993, 2740 µS/cm), TDS (2740 mg/l), TSS (2590, 900, 190 mg/l) and Chloride (1580, 1150,1900 mg/l) are out of the range of standard value. The remaining parameters which are indicated exceed the Bangladesh standard (ECR'97) for wastewater effluent.

Table 1: Test results of "Location 01: Aranghata"

Parameter	Unit	March 2019	May 2019	July 2019	September 2019	November 2019	January 2020	Standards for wastewater effluent (ECR'97)
BOD5	mg/L	2.3	2.8	3.3	2.5	2.6	3	50
COD	mg/L	12.14	77.8	160.77	14.34	58.96	83.57	200
pH	-	7.17	7.5	7.83	6.86	6.89	6.91	6-9
Turbidity	NTU	36.1	30.1	74.8	53	87.2	128	200
Color	Pt-Co	376	220	313	149	403	607	-
EC	µS/cm	**2780**	**1993**	**2740**	637	832	950	1200
TS	mg/100ml	2760	1700	5700	1400	1120	790	-
TDS	mg/100ml	**2740**	1690	3110	500	930	640	2100
TSS	mg/100ml	20	10	**2590**	**900**	**190**	150	150
TC	No/10ml	0	13	12	15	11	17	100
FC	No/10ml	0	7	0	1	0	5	100
DO	(mg/L)	3.5	4.2	4.6	3.6	4.0	4.3	4.5-8
Chloride	(mg/L)	**1580**	**1150**	**1900**	430	**624**	540	600
Nitrate	(mg/L)	0.89	0.85	0.059	0.8	0.7	0.9	10
Iron	(mg/L)	0.1	0.08	0	0.4	0.2	0.31	2
Sulfate	(mg/L)	86	63	23	12	17	11	400
Sodium	(mg/L)	1038	755.55	1248.3	282.5	389.67	354.78	-
Calcium	(mg/L)	17.52	16.9	16.4	11.70	9.78	8.90	-
Magnesium	(mg/L)	4.48	4.45	4.40	3.23	3.06	2.90	-
SAR	-	313	231.25	387	103.4	153.79	149	-

Table 2: Test results of "Location 02: Deana"

Parameter	Unit	March 2019	May 2019	July 2019	September 2019	November 2019	January 2020	Standards for wastewater effluent (ECR'97)
BOD	mg/L	2.1	2.7	3.6	2.6	2.4	1.9	50
COD	mg/L	129.05	163.43	**529.3**	160.77	134.68	112.82	200
pH	-	7.6	7.9	8.3	6.50	6.85	7.05	6-9
Turbidity	NTU	56	60.7	39	42.1	43.4	48	200
Color	Pt-Co	333	399	213	327	305	290	-
EC	µS/cm	730	531	507	338	402	418	1200
TS	mg/100 ml	590	560	1840	610	530	380	-
TDS	mg/100 ml	400	540	1600	560	440	340	2100
TSS	mg/100 ml	**190**	20	**240**	50	90	40	150
TC	No/10ml	14	8	13	22	12	19	100
FC	No/10ml	0	0	8	0	0	0	100
DO	(mg/L)	4.1	3.8	4.9	4.0	3.9	3.7	4.5-8
Chloride	(mg/L)	280	155	**660**	330	256	160	600
Nitrate	(mg/L)	0.1	0.7	0.1	0.2	0.1	0.6	10
Iron	(mg/L)	0.18	0.38	0.3	0.19	0.2	0.13	2
Sulfate	(mg/L)	1.0	30	0	0	1.0	1.0	400
Sodium	(mg/L)	183.96	102	433.62	216.8	168.2	57.12	-
Calcium	(mg/L)	8.32	10.12	20.9	9.2	8.1	7.8	-
Magnesium	(mg/L)	3.71	3.37	4.87	3.89	3.5	2.8	-
SAR	-	75	39.3	120.8	84.74	69.84	24.8	-

The table shows that, some wastewater quality parameters are in the range of the standard values mentioned in the "Environmental Conservation Rule, 97". These parameters include BOD, pH, Turbidity, conductivity, TDS, TC, FC, DO, Nitrate, Iron, Sulfate etc. Some of the values of COD (529.3 mg/l), TSS (190, 240 mg/l) and Chloride (660 mg/l) are out of the range of standard value. The remaining parameters which are indicated exceed the Bangladesh standard (ECR'97) for wastewater effluent.

Table 3: Test results of "Location 03: Botiaghata"

Parameter	Unit	March 2019	May 2019	July 2019	September 2019	Standards for wastewater effluent (ECR'97)
BOD	mg/L	3.8	3.4	2.6	2.8	50
COD	mg/L	**6213.21**	**3823.96**	**1910.6**	131.485	200
pH	-	7.30	8.05	5.85	6.53	6-9
Turbidity	NTU	5.13	58.6	29.7	63.1	200
Color	Pt-Co	52	296	289	204	-
EC	µS/cm	**6640**	**7000**	**6370**	612	1200
TS	mg/100ml	10560	8440	5690	1170	-
TDS	mg/100ml	**10200**	**7830**	**5460**	970	2100
TSS	mg/100ml	**360**	**610**	**230**	200	150
TC	No/10ml	0	0	0	25	100
FC	No/10ml	0	0	0	0	100
DO	(mg/L)	5.8	4.9	3.8	4.3	4.5-8
Chloride	(mg/L)	**5850**	**5900**	**3250**	390	600
Nitrate	(mg/L)	0.4	0	0	0	10
Iron	(mg/L)	1.0	0.63	1.36	0.46	2
Sulfate	(mg/L)	234	210	132	24	400
Sodium	(mg/L)	3843.45	6898.5	2135.25	256.23	-
Calcium	(mg/L)	21.32	23.26	25.32	9.70	-
Magnesium	(mg/L)	4.78	4.70	4.79	2.43	-
SAR	-	1063.93	1845	550.3	104	-

The table shows that, some wastewater quality parameters are in the range of the standard values mentioned in the "Environmental Conservation Rule, 97". These parameters include BOD, pH, Turbidity, TC, FC, Nitrate, Iron, Sulfate etc. Some of the values of COD (6213.21, 3823.96, 1910.6 mg/l), Conductivity (6640, 7000, 6370 µS/cm), TDS (10200, 7830, 5460 mg/l), TSS (360, 610, 230 mg/l), and Chloride (5850, 5900, 3250 mg/l) are out of the range of standard value. The remaining parameters which are indicated by red marks exceed the Bangladesh standard (ECR'97) for wastewater effluent. In this farm, shrimps are cultivated only one time in a year (February to July).

The values of the month of September 2019 are the water of Rupsha river before processing for the shrimp culture.

3.2 Possibility of reusing shrimp farm water as irrigation water

3.2.1 Water Quality Standard for Irrigation

Table 4: Irrigation water quality assessment with respect to BIWQS (DoE, 1997)

Parameter	Rate of Hazards	Water class
pH	5.1-6.4	No problem
	6.5-8.5	Moderate
	8.5-9.5	Sever
EC	<250	Excellent
	250-750	Good
	750-2000	Permissible
	2000-3000	Doubtful
	>3000	Unsuitable
TDS (mg/l)	<450	Good
	450-2000	Permissible
	>2000	Unsuitable
Cl^- (mg/l)	<80	No problem
	80-200	Moderate
	>200	Sever
Na^+ (mg/l)	<60	No problem
	60-180	Moderate
	>180	Sever
NO_3^- (mg/l)	<5	No problem
	5-30	Moderate
	>30	Sever
SAR	10-18	Good
	18-26	Doubtful
	>26	Unsuitable

3.2.2 Physical & Chemical Characteristics of Shrimp farm Water

The obtained pH value of water from Location 01, Location 02, Location 03 was found 7.19,7.37,6.93 which is close to 7 indicates that the water is suitable for irrigation purpose. The EC is used to estimate the salinity of water used for irrigation. It is used as a proxy measure for TDS concentration in water. The Shrimp farm water was within the allowed limit according to irrigation water classifications based on EC and TDS. Comparing with BIWQS (DoE, 1997), the value of EC in water is not exceeded the tolerance limit (2250 us/cm) for irrigation except 'Location 3'. The amount of chlorine in the water from the shrimp farm surpassed the tolerance limit (200 mg/l) for irrigation in Bangladesh (DoE, 1997). Nitrate concentration in Shrimp farm water was found in the tolerable limit. But the concentration of Sodium ion exceeds the tolerable limit (180 mg/l). As the sodium content is high, the SAR value was found to be high (>26). The average SAR values in Locations 1, 2, and 3 were determined to be 890.8, 69.08, and 223 correspondingly. The sodium adsorption ratio reflects how much irrigation water interacts with cation exchange processes in the soil. Excess sodium binds to soil particles, producing changes in soil properties and a reduction in permeability.

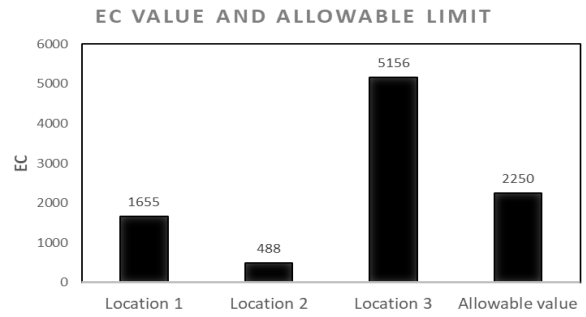

Figure 1: Comparison of EC with allowable limit for irrigation

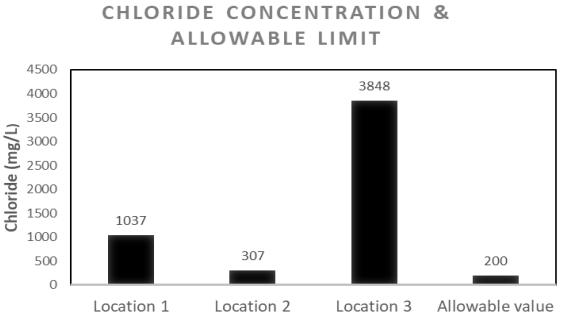

Figure 2: Comparison of Chloride concentration with allowable limit for irrigation

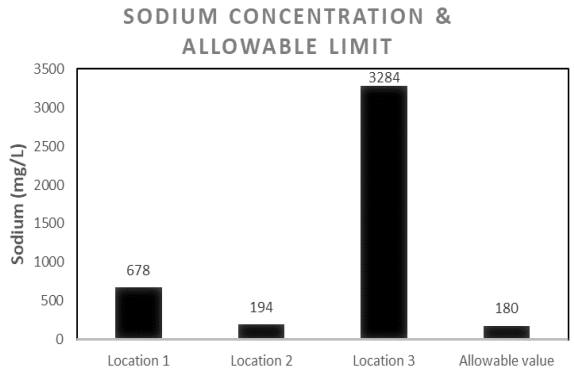

Figure 3: Comparison of Sodium concentration with allowable limit for irrigation

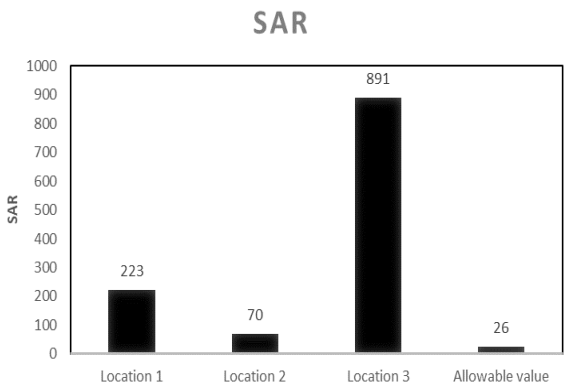

Figure 4: Comparison of SAR value with allowable limit for irrigation

4. CONCLUSIONS

In shrimp farming, a large quantity of water is wasted. With the scarcity of fresh water supplies growing in many arid and semi-arid regions of the world, the use of wastewater in agriculture is a centuries-old technology that is gaining renewed interest. For this study, the samples were collected from three selected shrimp farm in Khulna region at monthly intervals. The samples were tested and compared with the "Environmental Conservation Rule, 97". According to the findings of the tests, certain parameters such as COD, Conductivity, Total Dissolved Solid (TDS), Total Suspended Solid (TSS), Cl^- exceed the Bangladesh standard value (ECR'97). Other parameters are within the limit of standard values with regards to Bangladesh context. The results indicate that if the water disposed directly without treatment, it may cause potential thread for the aquatic life. Comparing the suitable values for irrigation water according to BIWQS (DoE, 1997) it can be concluded that the water of shrimp farms cannot be used directly due to very high salinity and SAR value. TDS, major cations (Na^+, Ca^{2+}, Mg^{2+}) and anions (Cl^-), values were not in tolerate limit. The water sample's SAR Index indicates that it is ineligible for irrigation as the Na^+, Ca^{2+} and Mg^{2+} were not in permissible limits. This water can be used after proper treatment.

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