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Physicochemical Analysis of Water for Assessing the Feasibility of Fish Cultivation in Jessore Municipality Ponds, Bangladesh.

Rafia Momota[1], S. M. Nayem Ahasan[2*], Abdullah Al Masud[3], Md Ashik-Ur-Rahman[4]

[1]Environmental Science Discipline, Khulna University, Bangladesh.
[2]Environmental Science Discipline, Khulna University, Bangladesh.
[3]Environmental Science Discipline, Assistant Professor, Khulna University Bangladesh.
[4]Environmental Science Discipline, Assistant Professor, Khulna University, Bangladesh.

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Corresponding Author
S. M. Nayem Ahasan
E-mail: *nayemahasan96@gmail.com*

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ABSTRACT

The present study investigates the different Physicochemical parameters of 8 ponds water in the Jashore district to identify whether the water quality in the ponds is feasible for fish cultivation. The samples were taken from various places in Jashore municipalities for preliminary analysis of Physicochemical parameters. Different physicochemical parameters of collected samples were analyzed. The result showed that the water quality parameters of all ponds were unsuitable for farming purposes with high electrical conductivity and temperature. At the same time, their nitrate levels were far lower than what was considered acceptable. The ponds have a very high bicarbonate concentration and obtained sample's Mg ion positively correlated with electrical conductivity ($P<0.05$). Additionally, bicarbonate ($P<0.05$) and pH ($P<0.01$) have a very significant connection with chloride ($P<0.01$). Electrical conductivity of the sample used has been demonstrated to correlate positively with magnesium ions. Bicarbonate and pH have a significant and profound link with chloride where sulfate and total soluble solids are correlated. The comparative investigation of the Physicochemical characteristics of water samples with the standard parameters was carried out periodically to develop the water source for fish cultivation in the future.

1. INTRODUCTION

Fish is the primary source of protein in the diet of Bangladeshis, making up nearly 60% of all animal protein (Shamsuzzaman et al., 2020). Per capita, fish consumption in the nation is 62.58 grams, which is more than their daily protein need (60 gm) (Bangladesh Bureau of Statistics, 2017). The importance of fisheries to the national economy as an agro-based nation and as the primary source of animal protein, employment opportunities, food security, foreign earnings, and social growth has always been undeniable (DoF, 2018). It adds about 24.41 percent to the agricultural GDP and 3.61 percent to Bangladesh's overall GDP (DoF,2018). The average growth rate of this industry during the last ten years has been close to 5.43 percent. In 2018, Bangladesh was ranked third globally for inland fish output, fifth globally for aquaculture production, and eleventh globally for marine fish production. Bangladesh is currently self-sufficient in producing fish and has begun to gain international prominence as one of the nations with the largest fisheries (Shamsuzzaman et al., 2020).

Ponds play a significant role in fish cultivation and maintaining ecology. Despite their tiny size, Ponds have essential environmental, social, and economic services, such as supplying drinking water, recharging groundwater, serving as sponges to regulate floods, sustaining biodiversity, and giving livelihoods through fish cultivation (Saha et al., 2017). Pond habitats often teem with lush flora and a vast array of organismal life. A pond is a more petite body of fresh water than a lake (F & O, 2017). Ponds are significant hotspots for fish cultivation and biodiversity. Collectively, they support more species and scarce species than any other freshwater habitat (Day & Biodiversity, 2016). They are also more abundant than almost any other freshwater habitat and are found in virtually all environments. Various problems have often hampered optimum fish production in culture systems, including a need for more information on fish cultivation setup and a lack of knowledge about pond water quality requirements for optimal fish production (Makori et al., 2017). Various chemical characteristics exist in low quantities in most bodies of water. This concentration level rises due to human activity and a lack of environmental management (Ehiagbonare & Ogunrinde, 2010).

Water quality is the water component that must be present for aquatic creatures to flourish optimally (Ehiagbonare & Ogunrinde, 2010). Identifying the fluctuation and ideal range of limnological parameters, such as pH, temperature, alkalinity, total hardness, potassium, nitrate, phosphate, and dissolved oxygen (DO), is essential for improving the primary productivity of fish cultivation pond water (Rukhsana et al., 2021). Productivity is determined by the physicochemical properties of the water body (Keremah R.I. et al., 2014).

Most fish in Bangladesh are found in wetlands, but we have an abundance of ponds in various parts of the country, allowing us to increase fish cultivation output and reduce the demand for fish consumption. Not only may it assist in reducing the annual demand for fish, but it could also contribute to economic growth and job creation. Therefore, using the urban pond for fish farming could be a viable solution to this problem. The investigation on the Physicochemical properties of surface water bodies (ponds) that are still and might be used for fish culture in the Jashore municipality of Bangladesh is presented in this paper. This study's goal is to determine the water's physicochemical parameters and assess the water's suitability for fish cultivation.

2. STUDY AREA

Jessore is a district in Bangladesh's southern region. Khulna and Satkhira are located to the south, Magura and Narail to the east, and Jhenaidah to the north. The region produces crops year-round. Employment in fish cultivation in Jashore decreased from 47,570 in 2005 to 46,050 in 2010. The transition from agriculture to industry and commerce increases the urban population. Urbanization continues. The population of Jashore is unevenly distributed. July 2019 was the month of the study. Surveyors investigated eight ponds in Jessore.

These ponds were chosen for the study because they may serve as a basis for optimal fish cultivation.

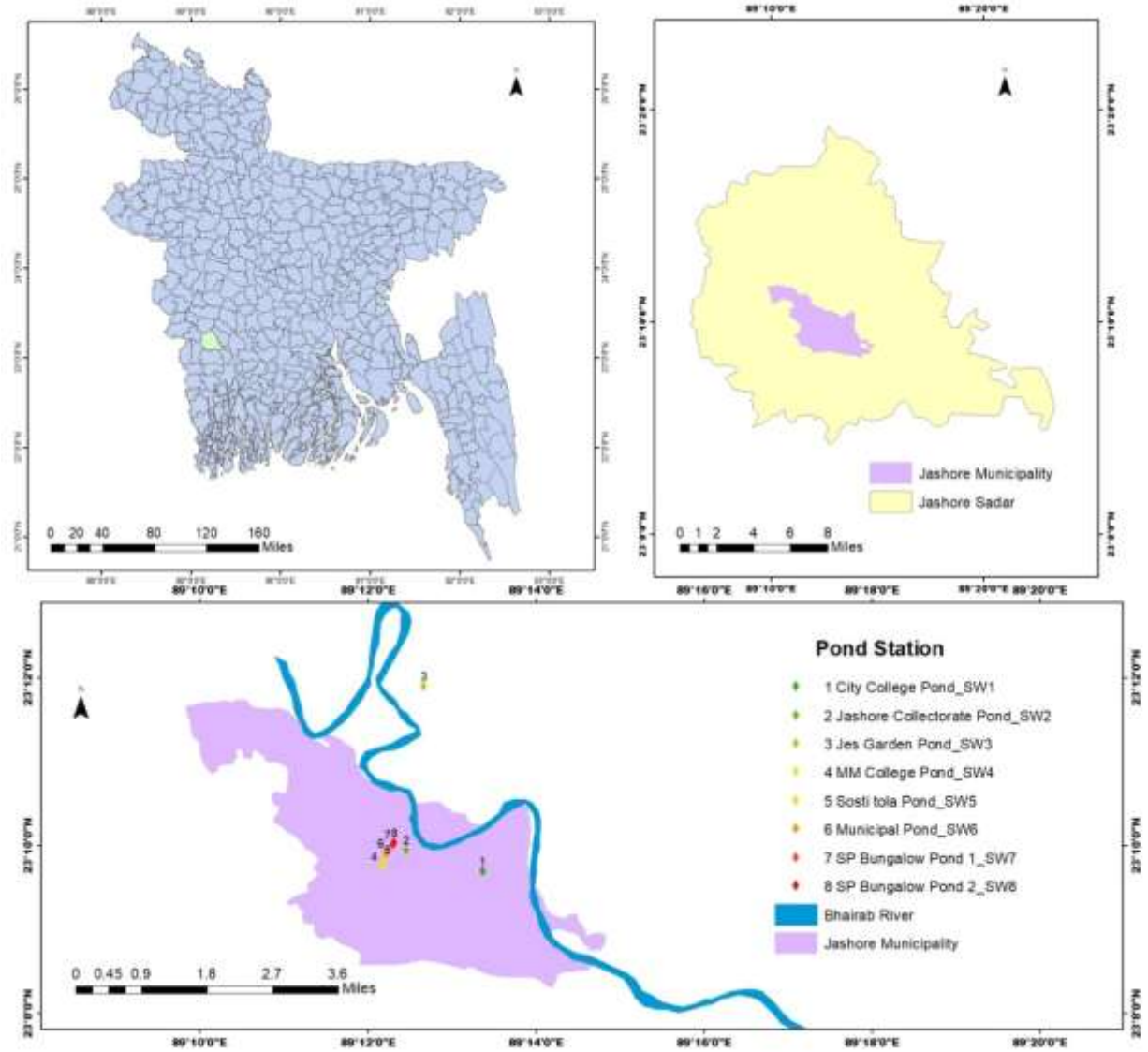

Fig 1: Demonstrate the location point of sample collection.

3. MATERIALS AND METHODS

This study follows the physicochemical qualities of water, which are essential for fish culture. It is the primary limiting factor in fish culture, which is often controlled by various factors, including color, odor, temperature, pH, DO, BOD, TDS, EC, transparency, acidity, alkalinity, and hardness (Boyd, 1990). There is an expected value for each of these variables in fish culture (James et al., n.d.). This section also discusses how to analyze different qualities using conventional methods. The selected pond's location is given in table 1.

Table 1: Jashore Municipal Ponds location

Sample no	Pond name	Main use of pond water	Latitude	Longitude	Number
SW1	City College Pond	Drinking in the of time scarcity and fishing	23.1615° N	89.2228° E	0/1
SW2	Jashore Collectorate Pond	Fishing	23.1657° N	89.2077° E	1/2
SW3	Jes Garden Pond	Fishing	23.1982° N	89.2112° E	2/3
SW4	MM College Pond	Fishing	23.1624° N	89.2029° E	3/4
SW5	Sosti tola Pond	Fishing	23.1638° N	89.2032° E	4/5
SW6	Municipal Pond	Fishing	23.1650° N	89.2038° E	5/6
SW7	SP Bungalow Pond 1	Fishing	23.1667° N	89.2049° E	6/7
SW8	SP Bungalow Pond 2	Fishing	23.1672° N	89.2053°E	7/8

A water sample (n=3) was obtained from each pond in a prewashed plastic container (5 liters in each) (5 liters in each). Immediately, the temperature was measured using a glass mercury thermometer. The conductivity/TDS electrode was rinsed with distilled water.

Typically, the pH scale ranges from 0 to 14, with pH seven at 25°C. A direct reading pocket pH meter electrically monitors the pH level. For calculating the potassium concentration, the flame photometric technique was used (ppm). Ca and Mg concentrations were determined using the titrimetric technique. To determine chloride, the Mohr titration technique was used. The bicarbonate concentration was determined using a potentiometric technique. By using a spectrophotometric technique, sulfate content was determined. The nitrate content in the sample was determined using an ultraviolet spectrophotometric screening technique. Using SPSS 21 software, simple correlation and regression were used to examine the data statistically.

4. RESULTS AND DISCUSSION

4.1 Water quality profile

The water quality profile for different ponds in Jeshore municipalities is provided in table 2. The pH range for all fish farms was 6.90 to 8.24, which is considered ideal for most species. For most freshwater organisms, a pH of 6.5 to 9.0 is considered optimum (Boyd, 1990). The pH range for pond water should be between 7 and 8 (CUMINGS, 1962). Fish have cold blood; hence the environment's temperature affects how hot or cold they are. It varies according to the ambient temperature. Temperature fluctuations impact fish production because they impact their physiology and metabolism (Kumar et al., 2017). Water at Jashore's pond ranged in temperature from 30.8 to 34°C. Due to the sample period falling in July, the temperature was high. Between stations, the average temperature is essentially the same. According to reports, the ideal pond water temperature for fish survival is 20 to 30 degrees Celsius (Jonassen et al., 1999).

Water cleanliness may be assessed using electrical conductivity (EC). It is influenced by the water's temperature and ionic content. A water body's conductivity correlates directly with the salts present (Bhatnagar & Devi, 2013; Kumar et al., 2017). Averaging 450.75 µS/cm, the electrical conductivity of all sample locations ranges from 270 to 653 µS/cm. The study found that the BOD value ranged from 1.8 to 2.9 mg/L. If BOD levels are high in the research region, more organic matter will be in the water body. This organic material originates from surface runoff, agricultural and forestry runoff, home wastewater, and municipal wastewater discharge. Less than five mg/l of BOD is the acceptable standard for fish culture (Das, n.d.) According to ("DoE Standards," 2004), a BOD level of 5 mg/l or more is appropriate for fish culture. The quantity of dissolved oxygen required varies depending on the type of animal. Given the findings and the fact that the primary productivity values at 20-30 ppm and 10-20 ppm were not significantly different. It is suggested that to maintain the best conditions for fish culture in wastewater fish ponds, a BOD level of 10-20 ppm may be continuously maintained through the split application of sewage effluent (Chattopadhyay et al., 1988). Too much or too little dissolved oxygen in the water may damage aquatic life and alter its quality. While shallow-water fish need larger quantities of oxygen (4–15 mg/l), bottom feeders like crabs, oysters, and worms only require a small amount (1-6 mg/l) (Singh & Kumar, 2016). All sample locations had TDS ranging from 241.20 to 606.20 mg/L. The research area's typical TDS situation is 396.49 mg/L. The TDS value is depicted in Table 2 for various stations.

By mixing oxygen and nitrite, the autotrophic Nitrobacter bacteria make the innocuous compound nitrate. Nitrate concentrations typically stabilize between 50 and 100 ppm (Bhatnagar & Devi, 2013). The range we found in our research for nitrite concentrations is presented in Table 3 (Boyd, 1990). When sodium and potassium levels are less than ten mg/L, potassium can equal or even exceed sodium in salt water, which has 390 mg/L. Biological and agricultural inputs in surface water create higher potassium concentrations (Hem, 1985). The average potassium content in the research region is 13.14 mg/L, ranging from 4.78 to 27.51 mg/L. A pond's water should have at least 20 ppm of calcium (hardness). More than 20 ppm of calcium is okay and will not be problematic (Crosby et al., n.d.). The average calcium content in the study region is 37.82 mg/L but ranges from 23.07 to 64.12 mg/L. However, the geochemical behavior of magnesium differs significantly from that of calcium. Magnesium is often not a limiting element in fresh water, although certain marine or brackish ponds that sustain marine organisms may need supplementation. Hardness and alkalinity levels in most waters are comparable and vary from less than 5 mg to over 150 mg/L (Claude E. Boyd, 2015; Sink et al., n.d.). The average magnesium content across all sample sites is 10.34 mg/L, ranging between 1.22 and 30.38 mg/L.

Table 2: water quality profile of different ponds in various location of jeshore municipalities, Bangladesh

Sample No	TDS (mg/L)	EC (µs/cm)	Temp (°C)	pH	BOD (mg/L)	DO (mg/L)	K^+ (mg/L)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	$HCO3^-$ (mg/L)	Cl^- ppm	NO_3^- mg/L	So_4^{2-}
SW1	217.5	359	37	7.76	1.9	7.6	4.37	13	4.8	442.25	21.3	0.88658	14.8469
SW2	160	526	34	7.90	2.1	6.3	2.966	10	6.6	366	17.75	0.16289	17.6203
SW3	152	270	32.3	7.45	2.6	6.5	2.858	10	6	398	16.98	0.90077	20.1956
SW4	157.2	653	33.7	7.59	2.9	5.9	4.01	11	6.6	440.15	17.35	0.4835	17.8184
SW5	149.5	370	31.8	7.72	2.4	5.5	3.598	12	5	289.75	14.2	0.93215	16.8279
SW6	212.5	626	35.7	8.24	2.5	6.4	3.89	14	7.2	444.35	24.8	1.0001	14.6488
SW7	154	436	36.3	6.90	2.2	6.3	3.689	10	6	335.24	10.65	0.8542	16.0355
SW8	245.2	330	32.1	7.10	1.8	5.3	2.987	12	5.4	320.25	14.2	0.64535	13.8924

Elevated chloride levels are one sign of water contamination used by scientists studying watersheds. Approximately 0.05 percent of the earth's crust is made up of chlorides. Freshwater typically has chloride concentrations between 1 and 100 ppm (parts per million) (Hunt et al., 2012). The average chloride content in the study region is 79.90 mg/L, with a range of 13.12 to 189.89 mg/L. The principal anion in groundwater, mainly from CO2, is HCO3-. Natural water typically has 500 mg/L or less of bicarbonate (TODD, 1980). A higher proportion of HCO3- denotes a chemical weathering process involving silicate or carbonate (Hem, 1985). With an average value of 187.95 mg/L, the bicarbonate concentration in the study region ranges from 109.80 to 289.60 mg/L.

According to research, sulfate concentrations in natural streams typically range from 0 to 80 mg/L, while they may surpass 1000 mg/L near industrial discharge sites, and 400 mg/L or higher concentrations may make water taste bad. Typically, natural water has a sulfate content of less than 300 mg/L (TODD, 1980), where the result fluctuates between 14.65 mg/l and 20.19 mg/l.

4.2 Correlation analysis of the parameters

The study results indicate that dissolved oxygen strongly correlates with temperature (table 3). Water may dissolve less oxygen as the temperature rises. Water is considered 100% saturated with oxygen when it can hold all the DO at a specific temperature. Under some circumstances (such as when algae are growing swiftly and producing oxygen more quickly than it can be used up or released to the atmosphere), water can become supersaturated with oxygen (Clean Water Team (CWT), 2004). It has also been observed that Mg ion has positively correlated with electrical conductivity ($P<0.05$) for the collected sample. Also, chloride has a strong significant correlation with pH ($P<0.01$) and bicarbonate ($P<0.05$) ions. As previously mentioned, mg ion has been shown to correlate positively with the electrical conductivity of the sample taken. In addition, chloride has a significant and influential relationship with pH and the ion bicarbonate. Moreover, finally, sulfate correlates with total dissolved solids, which is evident from the study. Despite this, a good association was discovered between the physicochemical properties of the water in different ponds located in different geographic areas (Rukhsana et al., 2021).

Table 3 Simple correlation coefficient of physicochemical parameters of various pond in Jeshore municipalities.

	Total Dissolved Solids(mg/l)	Electrical Conductivity (µs/cm)	Temperature (°C)	pH	Biological Oxygen Demand (mg/L)	Dissolved Oxygen (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate (mg/L)	Chloride (mg/L)	Nitrate (mg/L)	Sulfate (mg/L)
Total Dissolved Solids(mg/l)	1												
Electrical Conductivity (µs/cm)	-.101	1											
Temperature (°C)	.196	.324	1										
Ph	.064	.483	.151	1									
Biological Oxygen Demand (mg/L)	-.608	.485	-.201	.255	1								
Dissolved Oxygen(mg/L)	.082	-.052	.759*	.300	-.142	1							
Potassium (mg/L)	.140	.402	.684	.276	.137	.473	1						
Calcium (mg/L)	.693	.187	.279	.544	-.153	.160	.561	1					
Magnesium (mg/L)	-.179	.769*	.139	.364	.533	-.075	-.111	-.090	1				
Bicarbonate (mg/L)	.177	.476	.532	.512	.365	.660	.505	.327	.437	1			
Chloride (mg/L)	.394	.406	.367	.861**	.144	.521	.378	.674	.363	.792*	1		
Nitrate (mg/L)	.157	-.348	.176	-.018	.079	.204	.355	.496	-.299	.038	.130	1	
Sulfate (mg/L)	-.814*	-.095	-.397	-.002	.625	.021	-.395	-.705	.202	.063	-.172	-.207	1
*. Correlation is significant at the 0.05 level (2-tailed); **. Correlation is significant at the 0.01 level (2-tailed).													

4.3 Suitability analysis of the ponds water for fish cutivation

The parameters and their appropriate levels for fish cultivation are shown in Table 4. According to the relevant article, seven of the 13 factors are either inappropriate for fish culture or exceed the permissible value for most fish cultivation. Six criteria were determined to be within the permitted range for fish farming.

Table 4 Suitability of water quality parameters for fish cultivation.

Parameter	Maximum	Minimum	Suitability	Comment
TDS (mg/L)	217.5	149.5	For diversified fish development in fish culture, a maximum TDS value of 400 mg/l is allowed (Kumar et al., 2017)	Suitable
EC (µs/cm)	653	270	A freshwater body with healthy mixed fisheries has an EC range of 150 to 500 µs/cm (Munni et al., 2015).	Most of the pond's EC is higher than the optimum level.
Temperature (°C)	37	31.8	The optimum temperature for fish culture is 20-32 (°C) (Jonassen et al., 1999; Munni et al., 2015)	Most of the pond's temperature is higher than the optimum level.
pH	8.24	6.90	The optimal pH for both freshwater and marine water culture is 7.4, and the range (7-9) is acceptable for this (Boyd, 1990; Kumar et al., 2017).	Suitable
BOD (mg/L)	2.9	1.8	Less than 5 mg/l of BOD is the permissible BOD standard for fish culture (Das, n.d.)	Suitable
DO (mg/L)	7.6	5.3	The ideal amount for fish cultivationponds is 3.70-8.38 mg/l(Emerson et al., 2001; Munni et al., 2015).	Suitable
K^+ (mg/L)	4.37	2.858	According to experience, freshwater pond fish may thrive in water with potassium levels of 1 or 2 mg/L (Silapajarn et al., 2004).	Not suitable
Ca^{2+} (mg/L)	14	10	A pond's water should have at least 20 ppm calcium (hardness) (Crosby et al., n.d.).	Not suitable
Mg^{2+}(mg/L)	7.2	4.8	Alkalinity (Mg) levels in most waters are comparable and vary from less than 5 mg to over 150 mg/L(Claude E. Boyd, 2015).	Acceptable level
$HCO3^-$ (mg/L)	444.35	289.75	The most prevalent and significant alkalinity-related compounds are carbonates and bicarbonates. The optimal alkalinity level for an established pond should be approximately 100 ppm, while readings between 50 and 200 ppm are acceptable (Sallenave, 2012).	Not Suitable
Cl^- (mg/L)	24.8	10.65	Freshwater typically has chloride concentrations between 1 and 100 ppm (parts per million) (Hunt et al., 2012). (1 mg/l= 1ppm)	Suitable
NO_3^- (mg/l)	1.0001	0.16289	20 to 100 (mg/l) permissible for fish cultivation(T.V.R. Pillay, 1992)	Not Suitable
So_4^{2-}(mg/l)	20.1956	13.8924	The investigating group II guppies' embryos subjected to 1.0 mg/L of CuSO4 pentahydrate showed a number of defects (Lasienė et al., 2016).	Not Suitable

CONCLUSION

Assessing water quality is critical for maintaining quality fish production in the pond. When the results were in, it was evident that none of these ponds had suitable water quality for farming or culture due to high electrical conductivity and temperature levels. However, their nitrate levels were significantly lower than what was regarded acceptable. The findings of every water sample taken from the ponds indicate a very substantial concentration of bicarbonate. The correlation analysis of the water sample shows that the quantity of oxygen in the pond water substantially influences the level of DO and the pond water's temperature.

Similarly, chloride and sulfate ions affect the pH and TDS levels in the pond. On the other hand, Mg ion has a positive impact on the value of electrical conductivities. The current research provides baseline data for farm management and the optimal physicochemical range that aids in maintaining water quality throughout fish production. Most of the pond sample parameter values indicate that they do not satisfy the requirement for fish farming. We succeeded in achieving our primary goal of this study, which was to evaluate the water quality for fish farming suitability. However, the outcome needs to be more convincing for this purpose.

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