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Physicochemical Parameters and Heavy Metal Chromium Concentration in Fish Culture Ponds of East Kolkata Wetlands and Their Effects on Fish Health.

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Abstract

The extensive type of fish farming by utilizing wastewater into fishpond is a inimitable illustration of aquaculture thorough resource recycling in East Kolkata Wetland, Ramsar site in India. The current study exposed the pressure of urban effluence and poor management of use wastewater in the Ramsar site. The current paper lean-tos some lights over the quality of different water parameters and heavy-metal concentration of chromium content at EKW and their effects on prevalence of infection in fishes cultured at EKW area. Grounded on the recent study, it can be assumed that pollution level is increasing day by day at alarming rate, hence affecting the fish health severely in recent times. The incremental changes and proper management practice through pretreatment of sewage water, proper sanitation can easily solve some problems related to the pollution and fish health, may increase the fish production. Proper management practice can also reduce the probabilities of contamination of cultured aquatic organisms with perilous heavy-metals such as Chromium (Cr.) thus can also reduce the health hazards of the population of peri-urban Kolkata.

Keywords: East-Kolkata-Wetlands, fish culture, urban, pollution, physicochemical parameters.

Introduction

The Wetlands of Kolkata (EKW), the city's lungs, currently serves as a major dumping ground for wastewater and solid waste from the past. The project is the largest municipal wetland bionetwork in India and covers an area of 12,500 hectares including 286 acres of freshwater fish ponds with an area of 3832.27 hectares of water that covers almost 30% of the wetland-covered area. According to Chattopadhyaya et al. 2002, Kolkata Wetland is the main source of fish production and protein supply for the city's urban population, producing approximately 10,915 tons of fish per year. The agricultural wetlands of the surrounding wetlands consume solid waste for vegetable production and, in this case, more than 3000 tons of solid waste are regularly disposed of and used in the Dhapa area. These garbage bins are used properly and recycled to produce about

150 tons of vegetables a day, to fill the basic needs of the urban population. Often large amounts of liquid waste from domestic sources, even from industrial wells, are dumped in wetlands although several canals are used by nine pumping stations (DPS). In addition to this huge amount of sewage disposal from domestic source, the canals also carry a large amount of industrial industrial products from 538 tanneries, more than 5,500 small industries (including pottery, electroplating, dye production, rubber recycling, recycling) of batteries.) without environmental safety measures. Contaminated water is mixed directly with various fish ponds to be purified and used as fish feed or as fertilizer to produce natural organic food. The water purification system after the proper use of nutrients from domestic residues to grow fish in this wetland, eventually flows into the Kultigong River, about 40 kilometers from Kolkata. In this process a large amount of hazardous chemicals and waste from the leather, electroplating, and recycling units of batteries are mixed in farming and fish processing ponds such as fertilizers. Therefore, EKW and its bionetwork are thought to be at high risk of infection. The present study estimates the different coagulation of water and chromium heavy metals in different ecosystems of fish species in EKW and investigates the occurrence of various diseases and infections in fish that lead to death-related relationships with those parameters. In this study the focus of Chromium was more focused as it dealt with public health issues. Various recent studies by various authors have also focused on different types of heavy metallic pollution including chromium, as well as other important marine living resources related to fish health in the area (Chattopadhyay et al. 2002; Mukherjee), 2011; Dasgupta and Panigrahi, 2014; Mukherjee and Dutta, 2016; Kumar et al. 2018).

Materials and Methods

The contemporary study was conducted in different locations of Dhapa area, Chowbaga, Nalban, Mukundapur and Bantala at EKW area over a period of one year at monthly interval (March 2019 to February 2020). The foremost objective of the current study comprises to find out the effects of water-quality parameters and concentration of chromium on fish health. Major part of the work is based on data collection from the fish culture ponds of the area and correlation with the prevalence of the infection with those parameters to find out the actual causes of different types of infections related to the fish health. Another objective of the study is to take an idea about the different parameters and heavy metal chromium concentration in culture ponds. Heavy metals are directly connected to the human health, as the EKW is the major source of fish supply in urban areas. During the study various fish ponds were surveyed to collected water samples to measure the parameters like pH, hardness (2340C), alkalinity(2320B), DO (4500OC), biological oxygen demand (BOD) (5210B), chemical oxygen demand (COD) (5220B), nitrite (4500B), phosphate (4500PD), chlorine (4500ClB), chromium and moribund fishes. Fishes were gathered from the study areas with the help of fish catcher using cast nets. All the parameters are measured in the laboratory (except pH) following the standard method prescribed by APHA (1998). Only pH of the water was measured at the spot with handheld pH meter. Water samples were collected mainly from the midpoint of the pond by small boat either by hand or by sampler depending on the accessibility. The samples are mainly collected from the area between 6 am to 9 am morning.

The analytical results were processed using Microsoft excel and SPSS 21 software packages. Two tailed correlation coefficient was mainly utilized to find out whether there was any correlation found between the water parameters and chromium concentration with the prevalence of the infection.

Prevalence of Infection is calculated by the following formula –

$$\text{Prevalence of Infection (PR) \%} = \frac{Number\ of\ Infected\ Fishes}{Total\ number\ of\ collected\ sample\ fishes} \times 100$$

Results and Discussion

Different water parameters in wastewater along with heavy metal chromium concentration are presented in Table – 1 and the interrelationship of those parameters and with prevalence of the infection (PR) are documented in the correlation-matrix diagram in Table – 2.

Table – 1: Physicochemical Parameters of wastewater of EKW

Average Water Quality Parameters and Prevalence of Infected Fishes	Dhapa	Chowbaga	Nalban	Mukundapur	Bantala
pH	7.52	7.43	7.49	7.38	7.26
Hardness (mg/l of CaCO3)	784.52	871.63	796.52	849.36	778.61
Alkalinity (mg/l)	153.45	143.88	173.27	160.02	165.23
DO (mg/l)	4.30	4.90	4.67	3.50	4.13
BOD (mg/l)	45.58	42.95	44.84	72.83	46.98
COD (mg/l)	49.83	45.41	48.79	53.73	50.39
Nitrite (mg/l)	0.57	0.46	0.40	0.22	0.53
Phosphate (mg/l)	0.43	0.43	0.28	0.31	0.17
Chlorine (mg/l)	945.05	731.43	921.28	575.70	173.63
Chromium (mg/l)	0.36	0.26	0.35	0.22	0.36
Prevalence of Infected Fishes (PR) (%)	23.38	16.34	17.22	37.08	28.23

Table – 2: Correlation matrix of the average values of the physicochemical parameters of wastewater of EKW and prevalence of the infection in fishes (PR).

		PR	pH	Hardness	Alkalinity	DO	BOD	COD	Nitrite	Phosphate	Chlorine	Chromium
PR	Pearson Correlation	1	-.514	.002	.161	-.990**	.880*	.923*	-.522	-.376	-.526	-.394
	Sig. (2-tailed)		.376	.997	.796	.001	.049	.025	.367	.533	.363	.511
	N	5	5	5	5	5	5	5	5	5	5	5
pH	Pearson Correlation	-.514	1	.041	-.161	.411	-.252	-.298	.084	.749	.996**	.108
	Sig. (2-tailed)	.376		.948	.796	.492	.683	.627	.893	.145	.000	.863
	N	5	5	5	5	5	5	5	5	5	5	5
Hardness	Pearson Correlation	.002	.041	1	-.611	.065	.346	-.233	-.563	.474	.100	-.914*
	Sig. (2-tailed)	.997	.948		.274	.918	.569	.707	.323	.420	.873	.030
	N	5	5	5	5	5	5	5	5	5	5	5
Alkalinity	Pearson Correlation	.161	-.161	-.611	1	-.234	.110	.444	-.204	-.769	-.145	.432
	Sig. (2-tailed)	.796	.796	.274		.705	.860	.454	.742	.128	.815	.468
	N	5	5	5	5	5	5	5	5	5	5	5
DO	Pearson Correlation	-.990**	.411	.065	-.234	1	-.886*	-.966**	.533	.357	.425	.341
	Sig. (2-tailed)	.001	.492	.918	.705		.046	.008	.355	.555	.475	.574
	N	5	5	5	5	5	5	5	5	5	5	5
BOD	Pearson Correlation	.880*	-.252	.346	.110	-.886*	1	.831	-.845	-.154	-.228	-.696
	Sig. (2-tailed)	.049	.683	.569	.860	.046		.081	.072	.805	.712	.192
	N	5	5	5	5	5	5	5	5	5	5	5
COD	Pearson Correlation	.923*	-.298	-.233	.444	-.966**	.831	1	-.522	-.428	-.312	-.182
	Sig. (2-tailed)	.025	.627	.707	.454	.008	.081		.367	.472	.610	.769
	N	5	5	5	5	5	5	5	5	5	5	5
Nitrite	Pearson Correlation	-.522	.084	-.563	-.204	.533	-.845	-.522	1	.114	.017	.783
	Sig. (2-tailed)	.367	.893	.323	.742	.355	.072	.367		.855	.978	.117
	N	5	5	5	5	5	5	5	5	5	5	5
Phosphate	Pearson Correlation	-.376	.749	.474	-.769	.357	-.154	-.428	.114	1	.738	-.284
	Sig. (2-tailed)	.533	.145	.420	.128	.555	.805	.472	.855		.154	.643
	N	5	5	5	5	5	5	5	5	5	5	5

Chlorine	Pearson Correlation	-.526	.996**	.100	-.145	.425	-.228	-.312	.017	.738	1	.053
	Sig. (2-tailed)	.363	.000	.873	.815	.475	.712	.610	.978	.154		.932
	N	5	5	5	5	5	5	5	5	5	5	5
Chromium	Pearson Correlation	-.394	.108	-.914*	.432	.341	-.696	-.182	.783	-.284	.053	1
	Sig. (2-tailed)	.511	.863	.030	.468	.574	.192	.769	.117	.643	.932	
	N	5	5	5	5	5	5	5	5	5	5	5

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

During study total mean chromium (Cr) concentration 0.22 to 0.36 mg l^{-1} in the current study areas. The major causes of the chromium in EKW are electroplating industries and tanneries beside EKW area. Another study also done by Chattopadhay et al., 2002, based on physicochemical parameters of the aquatic environment in same location, were reported 0.05 to 0.20 mg l^{-1} was much less from the current study indicates gradual increase of chromium concentration at EKW in recent years. According to Central Pollution Board (CPCB, 1997) of India, the optimum concentration of Cr. in water should not exceed 2.0 mg l^{-1}. The measured value of the current study though much less than the alarming Cr. concentration in water. However, correlation matrix does not indicate any such connection between prevalence of the infection in fishes (PR) and chromium concentration of wastewater. Though the concertation is significantly correlated (negative) with the hardness of the water ($P<0.05$).

The current study indicates the average pH value of the waste water is in between 7.26-7.52. As those fish culture ponds are regularly monitored and maintained with lime to control the pH and alkalinity level, the pH is almost near to the optimum value of fish culture as described by Bhatnagar et al., 2004. The correlation matrix also does not find any correlation between PR and average pH value because the pH of the water is controlled to the optimum level. Though, there is a significant positive correlation is found between chlorine concentration and pH value of the water ($P<0.01$). The current mean pH value is very close to the study conducted by Chattopadhyay et al., 2002.

Same as pH value of the water, the alkalinity concentration of water is almost optimum to the ideal level (143.88-165.23 mg l^{-1}) as reported Stone and Thomforde (2004). The correlation matrix also does not find any correlation between PR and average alkalinity value because the alkalinity of the water is controlled to the optimum level by the fishermen.

On the other hand, the hardness of the waste water is found very high 778.61 to 871.63 mg l^{-1}. Though according to Bhatnagar et al. (2004), the value of hardness greater than 300 mg l^{-1} is lethal to ay fish culture system, the current study does not find any correlation between PR and hardness of the water. Even there is no such mass mortality reported during the recent time with this high hardness value. The current level of hardness also reported by Chattopadhyay et al., 2002 in the same location they studied with no such mass mortality report. The hardness of the water is significantly correlated (negative) ($P<0.05$) with chromium concentration of the wastewater.

The dissolved oxygen concentration of water (DO) is measured during the study in between 3.50-4.90 mg l^{-1} which is less to the optimum level required for the fish culture according to Bhatnagar and Singh (2010) and Bhatnagar et al. (2004). The correlation matrix also found a significant negative correlation between dissolved oxygen concentration of water and PR. Though Bera et al., 2021, found a significant negative correlation between DO, inorganic phosphate and nitrogen concentration of water, the current study doesn't not find any correlation between those parameters. The current concentration of DO content in waste water is found similar to the study conducted by Dasgupta and Panigrahi, 2014, Bera et al., 2021.

BOD level of the waste water in the current study is much higher 42.95 to 72.83 mg l^{-1} than the recommended value prescribed by Ekubo and Abowei (2011). Though at very high level, there is no such mass mortality occurs in EKW. But correlation matrix indicates there is a positive correlation ($P<0.05$) between PR value and BOD of the waste water. BOD is also having negative significant correlation with DO content of the water ($P<0.05$). The release of raw sewage directly through the canals in EKW without prior treatment increase the BOD content of water, and such high level of BOD in wastewater fed pond due to the higher level of pollution is a challenge to the fish farmer. Much higher result of BOD was measured by Chattopadhyay et al., 2002 in the same location. Dutta et al., 2010, reported average BOD level 30-37 in sewage fed fish culture ponds.

COD level of the waste water similarly as high as BOD level in EKW ponds as reported by Dutta et al., 2010 (58-65 mg l^{-1}) and Adhikary et al., 2019. compared to the current study 45.41-53.73 mg l^{-1}, indicating higher pollution level in EKW fish culture ponds. The variation of high COD value in EKW refers highest level of the pollution load leads to the highest PR of infection and mortality throughout the year. The correlation matrix indicates same result as BOD, here COD is positively correlated with PR ($P<0.05$). Much higher COD value than the current study was reported by Chattopadhyay et al., 2002 (376-15111 mg l^{-1}). The correlation matrix indicates there is a positive correlation ($P<0.05$) between PR value and BOD of the waste water, hence COD is also responsible for sickness and mortality of the fish in EKW. COD is also having strong negative significant correlation with DO content of the water ($P<0.01$).

The parameters like nitrite, phosphate and chlorine does not affect fish health in EKW according to the correlation matrix as those are not significantly related to PR of the fish. The average value of nitrite in EKW varies between 0.22 mg l^{-1} to 0.57 mg l^{-1} which is much higher than Dutta et al., 2010 and Adhikary et al., 2019 indicating higher pollution level in recent years. Santhosh and Singh (2007) described the favorable range of 0.1 mg l^{-1} to 4.0 mg l^{-1} in fish culture water indicating that the current level is much lower than optimum range. On the other hand, mean phosphate level of EKW varies between 0.17 to 0.43 mg l^{-1}, which is higher than Dutta et al., 2010 (0.16-0.18 mg l^{-1}). Phosphorus (P) always is present in aquatic environment in the form of phosphate (PO_4). The phosphate is mainly combined to living and dead particulate matter. Bhatnagar et al. (2004) recommended 0.05-0.07 ppm is ideal and productive; 1.0 ppm is decent for plankton / shrimp production. In present study the phosphate level is found in acclaimed ideal level and does not making any problem to the fish health.

The above results and discussion from current study established the dominance of industrial and domestic ejection to the sewage fed fish culture ponds relating to the health of the fish cultured in those areas. DO, BOD and COD plays primary role to the fish health in EKW. Though chromium concentration in EKW is increasing day by day, does not play major role to the fish health issues, though bioaccumulation may lead human health hazards.

Conclusion

The waster water and its use in fish culture pond clearly exposed the robust impact of urban pollution. The deterioration of the quality of water in EKW cause irreparable loss of pond bionetwork, related to the poor fish health and poor production of fishes. The direct utilization of sewage water in the fish pond may lead bioaccumulation of the pollutants leading human health hazards in coming decades. Our present study clearly indicates the status of EKW water is eutrophic and becoming more hazardous for fish cultivation and human health. Though based on the observations, it can be concluded that the EKW, the largest sewage fed wetlands is currently suitable for fish culture, but water quality is deteriorating day by day, due to the pressure of urban population, anthropogenic activities, industrial effluents, lack of proper sanitation. Therefore, highest priority should be given to the pretreatment of the sewage water and water quality monitoring to obtain better result and proper use of this highly valued wetland in future.

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