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Biological Oxygen Demand in Controlling Fish Production and Cost of Supplementary Feed towards better Sustainability of a Sewage-Fed Aquaculture System: A Case Study of East Kolkata Wetlands, West Bengal, India

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Abstract

East Kolkata Wetlands on the eastern part of Kolkata city, a Ramsar site is known for integrated resource recovery practices through single pond system, which is the largest and perhaps the oldest in the world. This resource recovery practice is facilitated by presence of different ecosystems at micro levels distributed through the whole wetland area. These ecosystems play a major role in converting waste to resource. The waste water of Kolkata city enters through a main canal and gets distributed throughout the area. The waste water with organic loading which is expressed as Biological Oxygen Demand (BOD), is the source of fish food. These organic wastes are biodegradable, they degrade by natural process and release minerals, which through food chain enter into fishes' system thus saving the cost of fish feed. Present study through primary data analysis provides an insight about the effect of BOD on fish production towards better sustainability of this system.

Keywords: Biodegradable; Mineralization; Micro-ecosystem; Sewage-rectification; Physico- chemical

Introduction

East Kolkata Wetlands (EKW) with 286 commercially operating fisheries or bheries (local name of the fisheries), covering an area of 2480 hectors (unit for measurement of area) plays a major role in purifying the sewage of Kolkata city. The technology is devised by the fish farmers themselves. The sewage (both domestic and industrial wastes) from different parts of the city through four pumping stations by two main canals enters into the huge waste recycling zone of EKW. The two main canals are Dry Weather Flow Canal (DWF) and Strong Weather Flow Canal (SWF). Major part of waste is channelized through DWF canal and SWF canal carries diluted waste directly into the final discharge point. The sewage coming through DWF canal gets channelized into many ancillary canals known as Fishery Feed Canals (FFC) to enter into the fish ponds where the sewage is retained for some days for treatment along with fish cultivation. Fish ponds are distributed on both sides of the main DWF canal. The distribution of the ponds on both sides of the main canal is not homogeneous and the ponds do not get uniform sewage supply both quality as well as quantity wise. The quality of sewage is conventionally determined by measuring some important properties such as BOD, COD etc that arises due to some complex physico-chemical and biotic interactions within the system [1]. In the present paper BOD is considered for analysis, as it is the indicator of biodegradable organic content in the sewage, which acts as fish food.

This study attempts to see the effect of BOD on fish farming. The objective of this paper is to understand through data analysis, the probable impact of Biological Oxygen Demand (BOD) on the fish productivity and also on the supplementary-feed cost in such a sewage-fed fishery towards better viability.

The process of sewage rectification in the fish ponds at EKW

The rectification of sewage happens throughout the area of the wetlands and in different parts, where existing micro-system facilitates the process. This rectification process starts from the main canal through which waste enters in this zone, the DWF canal, from there, waste passes through ancillary canals, the rectification happens within the ancillary canals as well. Hence as the waste passes through the canals the BOD value decreases and the potentiality of waste as resource (fish food) also decreases.

The sewage rectification in the fish ponds of EKW happens majorly through two processes i.e. pond preparation and regular feeding of sewage water in the fish ponds. Pond preparation constitutes an essential step in waste purification at EKW. In this process, mostly done during winter (November to March), water from the pond is removed. Thereafter, the bottom mud is ploughed and lime is applied and the whole pond is kept for sun drying for around one month. Next the raw sewage is allowed to enter the pond to a depth of about 90 cm [2]. At this time the colour of the water remains black. Within a week the colour starts turning green due to formation of algae, within 10-15 days the algae grows to the full extent and after removing the algae the water becomes clear. This water is still kept for few days to offer the sunlight to enter and after that fish cultivation starts. Another important way of sewage rectification is during fish cultivation, sewage is discharged into the pond on a regular basis, such that the pond remains healthy and constant supply of nutrients is also maintained. Generally sewage is fed in the fish ponds in a ratio of 1:4, which means 1/4th part is fed with sewage [3], thus it gets rectified and at the same time fish cultivation is done. The treated water is regularly discharged

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from the ponds into the exit channel and finally discharged into the main disposal point.

The conventional system of sewage treatment has three ponds used in a sequential manner. But the uniqueness of the ecology based sewage treatment technique at EKW, empirically adopted by the fish farmers is that, here instead of three different ponds only one pond is used, hence all physico-chemical activities occurring during sewage treatment confined only in one pond. Therefore the waste purification in this pond at EKW is quite different from the conventional process [4].

Ecological logic behind the role of BOD in waste water fed fisheries

The fish ponds of East Kolkata Wetlands are fed with sewage water but all the 286 ponds are not fed equally as the availability of sewage varies throughout the area. The whole area of EKW can be differentiated into zones based on the quality and availability of sewage. The quality of sewage is expressed as BOD and higher BOD means organic component of the waste is more. These organic components with time degrade and mineralize releasing nutrients, which through food chain reach fish system and thus serve as fish food and in this process sewage also gets rectified.

It is true that BOD is an indicator of pollution level and BOD has an inverse relationship with dissolved oxygen, hence increased BOD might be harmful for aquatic life. This problem is mitigated by two fold factors at EKW. The depth of the fish ponds vary between 50 cm to 150 cm, this shallow depth allows full vertical circulation of water to the surface. This is also favourable for photosynthesis due to better ratio between pond volume and pond surface than a deeper pond. This helps providing sufficient oxygen for efficient BOD reduction [5]. Above all the farmers have acquired considerable skill and experience in feeding the ponds with raw sewage to avoid de-oxygenation, thus maintaining a healthy aquatic system.

Study area

The whole of East Kolkata Wetlands area lies between latitude $22^{0}25$” to $22^{0}40$” N and longitude $88^{0}20$” to $88^{0}35$”E. This region consists of water spread area of 4728.14 hector agricultural land area 4959.86 hector and urban and rural settlement 1326.52 hector. Total number of fish ponds is 364, distributed on both sides of the main sewage canals, out of which 286 ponds are used for commercial aquaculture practice through sewage water [6].

This region is suitable for solar radiation. Annual mean rainfall is 200 cm, maximum temperature in summer raises up to 40^{0} C minimum temperature in winter is 9^{0}-10^{0} C. The average temperature during day time in most part of the year is 30^{0}C with a fall of 4-5^{0} C at night (Figure 1).

Method

Objective of the study involves two major aspects quantity of fish produced and supplementary feed cost. Selection of method was done accordingly, on one hand getting the cost and productivity related data and on the other hand getting the BOD value. Major part of the work is based on primary data analysis. The cost and productivity related information was collected directly by survey with specific target population. BOD measurement was done by collecting sample from selected ponds.

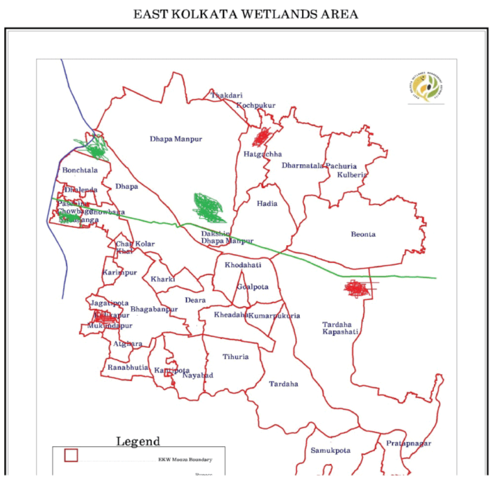

Figure 1: The map shows study area, red marked areas for weak zone and the green marked areas for strong zone and green line represents main DWF canal.

Sample selection

Sample selection was done based on available secondary data and discussion with experts. Sample has been taken from six selected regions based on certain criteria to make it a representative of the whole area. The criteria has been set to incorporate the maximum possible variations.

The fish ponds are distributed on both sides of the main canal. The main waste water canal, i.e. DWF canal enters from one side (along the green line in the map) hence the ponds on both sides are not equally fed with waste water. Based on the quality of waste water entering into the ponds the whole area can be approximately differentiated into two zones (though there is no demarcation). The portion which is nearer to the main canal receiving better quality of waste water is considered as strong zone, the portion away from the main canal receiving poor waste water as weak zone (strong and weak considering productivity, according to the information provided by the experts). Hence to understand the effect of BOD, in the present study bheries were selected both from strong and weak zones. Among the six selected ponds, three ponds from strong and three from weak zones were taken. Again these ponds were also selected considering the spatial distribution of the area and the variation in the size. All the ponds were selected from five different mouza (locally used physical demarcation system of land), Dhapa-Manpur being the largest mouza, two bheries were selected from this area. Management pattern of the bheries was also considered, most of the bheries are run by private parties on lease, a very few are run by farmer cooperatives and government. Among the six selected bheries one is run and managed by State Fisheries Department, Government of West Bengal and others are by private parties.

Primary data collection

Primary data regarding cost and production were collected by interview method. For this purpose questionnaire was prepared. It took around a month time to complete the survey. The target population included the lease holders (people who take lease from the owner) and labourers from each bheri, as they are the key people associated with fish farming. For 6 bheries 6 lease holders and 12 labourers were interviewed. For each bheri lease holders are the main cost related information providers, the labourers were interviewed to understand the process of fish farming (Table 1).

Sl	Name of the bheri	Location (Mouza)	Zone	Productivity Kg/ha/yr	Cost of supplementary feed Rupees(Rs)/ hector/year
1.	Nalban	Dhapa-Manpur	Strong	4871 kg/ha	1430
2.	Chowbagha	Choubagha	strong	4556 kg/hector	2340
3.	Bantala 2	Dhapa-Manpur	strong	4265 kg/h	3300
4.	Jhagrasisha	Hatgachha	weak	2938 kg/h	7047
5.	Kantatala	Tardaha Kapasite/KLC PS	weak	2500 kg/ha	9394
6.	Purbakolkata	Kalikapur Mouza/Tiljala PS	weak	2089 kg/hector	10,938

Table 1: Survey findings at-a-glance.

BOD measurement

Samples were collected from different ponds located in different zones, and BOD estimation was done by standard method in laboratory. The BOD of waste water shows seasonal variation, in winter the BOD value is comparatively higher and during monsoon the waste gets diluted and BOD decreases, hence sampling was done in 5 difference months in a year (March, May, July, September, December) to incorporate all the possible variations and the average value was considered in the final analysis (Table 2).

Locations	March 2014 (BOD mg/l)	May 2014 (BOD mg/l)	July 2014 (BOD mg/l)	Sept. 2014 (BOD mg/l)	Dec. 2014 (BOD mg/l)	Average (BOD mg/l)
Nalban	37	47	24	20	65	38.6
Chowbaga	31	33	21	15	63	32.6
Bantala 2	30	31	20	14	60	31
Jhagrasisha	20	25	17	14	33	21.8
Kantatala	18	27	12	12	30	19.8
PurbaKolkata	16	20	12	10	25	16.6

Table 2: BOD value at different locations.

Result and Discussion

This paper attempts to understand the relationship of BOD with the cost of supplementary fish feed and the fish production by primary data analysis. The collected information was calculated to generate following categories of data. Both production and cost related data are annual data (2014-15).

By comparing the data in the following tables it is clear that there exists a relationship among BOD, cost and productivity in all the six locations. From location A to location F in Table 3 BOD value gradually decreases and cost of supplementary food increases and in Table 4 BOD decreases and production also decreases.

Variables/ Parameters	Locations					
	A	B	C	D	E	F
BOD (mg/l)	38.6	32.6	31	21.8	19.8	16.6
Cost of supplementary food(Rs/ha/yr)	1430	2340	3300	7047	9394	10938

Table 3: Comparison between BOD and cost of supplementary food at different locations.

Variables/ Parameters	Locations					
	A	B	C	D	E	F
BOD (mg/l)	38.6	32.6	31	21.8	19.8	16.6
Production (Kg/ha/yr)	4871	4632	4265	2938	2500	2089

Table 4: Comparison between BOD and fish production at different locations.

From Figure 2, it is clear the relation between BOD and productivity is almost linear and direct and Figure 3 is showing the relation between BOD and cost is almost linear but inverse. For Nalban, Chowbaga and Bantala 2 bheries, BOD is decreasing proportionately (Tables 3 and 4), these three bheries are located in strong zone and more or less along or nearer the main DWF canal. But other three bheries Jhagrasisha, Kantatala and Purba kolkata located in weak zone, BOD value decreases considerably (Tables 3 and 4) and the cost and productivity is affected. Hence it shows BOD has got measureable implication on both cost and productivity.

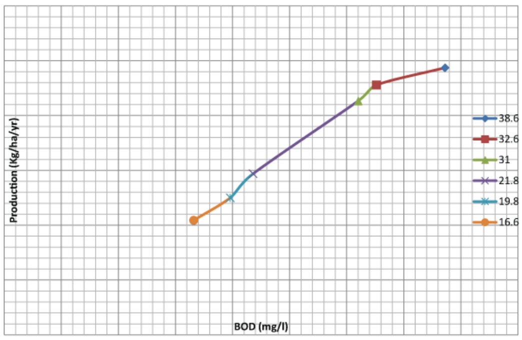

Figure 2: Showing variation of fish production with BOD.

Lets consider two situations, situation I, is comparison between one bheri from week and another from strong zone i.e. between Bantala 2 and Jhagrasisha, these two are having minimum difference in BOD compared to others. Here, when the difference in BOD is 9.2 mg/l, the cost difference is Rs 1544/-/ha (Table 3) and the productivity difference is 411 kg/ha (Table 4), which is a clear indication of how the change in BOD value is changing the production and cost in a sewage fed fishery.

Situation II, is the same comparison within two strong zone bheri and two weak zone, for strong zone comparison between Nalban and Chowbaga bheri give the result as, for decrease of BOD 6 mg/l, the cost increases Rs 910/-/ha (Table 3) and productivity decreases 239 kg/ha (Table 4) and in weak zone, between Kantala and Purbakolkata, decrease in BOD of 3.2 mg/l causes increase in cost of Rs 1544/-/ha (Table 3) and decrease in production of 411 kg/ha (Table 4).

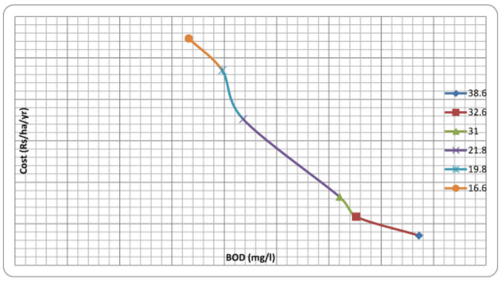

Figure 3: Showing the relation between BOD and cost of supplementary feed.

It is interesting to note that, in strong zone though the BOD value is decreasing 6 mg/l but the difference in cost and production is not that much compared to the other situation where, both in weak zone and decrease in 3.2 mg/l of BOD (almost half of half of the earlier) the effect is almost twice both in cost and productivity. One inference can be drawn that, in the second case as the BOD is already low hence the effect is much pronounced compared to the first case.

Conclusion

From the above discussion it can be inferred that BOD value is having considerable effect on fish production and supplementary feed cost in a sewage fed fishery. The fish farmers consider the waste water as "gold" and if they get required quantity of this there will be minimum requirement of supplementary feed. It also came very strongly at the time of information collection that, access to right quality waste water is a serious problem especially in the fisheries away from the main canal. Hence to sustain this sewage fed fish cultivation in a more commercial way certain issues must be taken care of to attract the next generation of the fish farmers into this profession and to make the whole thing sustainable.

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