USE OF NON-LINEAR AUTOREGRESSIVE MODEL (NAR) TO FORECAST THE FUTURE HEALTH OF SHRIMP FARM

Pallavi Dutta¹, Mourani Sinha², Prosenjit Pramanick³, Sufia Zaman⁴
Abhijit Mitra⁵

¹Faculty Member, Charuchandra College, 22 Lake Road, Kolkata 700029, India
²Associate Professor, Department of Mathematics, Techno India University, West Bengal, India
³Research Scientist, Department of Oceanography, Techno India University, West Bengal, India
⁴Associate Professor & HOD, Department of Oceanography, Techno India University, India
⁵Faculty Member & Former Head, Department of Marine Science, University of Calcutta, India

Email: ¹pallavidutta83@gmail.com, ²mou510@gmail.com, ³ppramanick660@gmail.com, ⁴zamansufia123@gmail.com, ⁵abhijit_mitra@hotmail.com

Corresponding Author: Pallavi Dutta

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Abstract

Microbial load in terms of Total Coliform (TC) and Fecal Coliform (FC) were documented in the water of a shrimp culture farm at Malancha region of North 24 Parganas for a period of 36 years (1984-2019). The region receives the wastewater from the city of Kolkata. A steady hike in the microbial load (comprising of both total and fecal coliform) is noticed. The primary reason behind this rise of the microbial load is the run-off from the nearby landmasses that brings various types of wastes in the shrimp farm under investigation. The sustainability of shrimp farms in this region is under question due to the huge microbial load as revealed from the output of NAR.

Keywords: Total coliform (TC), fecal coliform (FC), shrimp culture, Malancha in North 24 Paraganas, Non-linear Auto Regressive model (NAR)

I. Introduction

The city of Kolkata with a huge population density is the source of different categories of wastes that find their way through DWF and SWF canals in the water

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bodies located at the outskirt of the city. These water bodies are mostly used for culturing shrimp, which has high demand in the internal and foreign markets. The aquatic ecosystem provides several benefits to mankind in the field of public consumption, industry, fish farming, agriculture, tourism, several ritual activities, etc. Hence, up-gradation of water quality is of utmost importance to receive the optimum ecosystem services from the aquatic phase. Several diseases like typhoid, jaundice and many others are caused due to water pollution [II]. A wide range of literature is available where the water quality change has been highlighted during the last few years [VII], [VIII] due to anthropogenic activities. The most common biological pollutants include the microbes that encompass the coliform group of bacteria. Microbial load in the shrimp farm is very common and is sourced from uneaten decomposed feed, carcasses of dead fishes, etc. Run-off from the adjacent landmasses to the shrimp farming units also introduces considerable microbial load in the aquatic phase.

The surroundings of the selected shrimp farm in the Malancha area are characterized by the presence of fish markets, brick kilns, and urban settlements. Hence, the shrimp farms in this region receive untreated wastes of all categories resulting in the propagation of coliform group of bacteria. Based on the stated background matrix, our team initiated the investigation in 1984 during June and completed the programme in 2019. The data bank developed during this span of 36 years (1984-2019) served as the base of the nonlinear autoregressive model (NAR) to forecast the microbial load in the aquatic phase of the selected shrimp farm. The primary aim of this research is to evaluate the sustainability of the shrimp farming system in coastal West Bengal using the present shrimp farm as a representative model.

II. Materials and Methods

The present study encompasses the evaluation of total coliform and fecal coliform by analyzing the water samples collected from five different spots of the same shrimp farm at Malancha region in the North 24 Parganas district of West Bengal. The collection of water samples was carried out from the selected pond and brought to the Kolkata laboratories for further analysis. Most Probable Number (MPN) method [I], [IV], [V], [VI], [XIV] was used in this study for the measurement of total coliform, fecal coliform in surface water samples, and the results are presented as MPN/100ml.

The nonlinear autoregressive model was finally applied to forecast the counts of total coliform and fecal coliform in the water of the Malancha shrimp farm to analyze the sustainability of shrimp farming practices presently operating in the area. The general architecture of the neural network training is highlighted in Fig. 1.
Fig 1. The architecture of the Non-linear Auto-Regressive (NAR) model for forecasting the total and fecal coliform counts in the aquatic phase of shrimp farms at Malancha

III. Results and Discussions

In India, the aquaculture sector is primarily dominated by shrimp culture, although in many maritime regions like Goa, Tuticorin, etc., oysters and seaweed culture are also carried out. In West Bengal, shrimp culture by improved traditional method is carried out in North 24 Parganas district particularly in areas like Malancha. The culture is backed up with the wastewater of the city of Kolkata, which has a high nutrient load that accelerates the growth of phytoplankton, the natural feed of the cultured shrimp. However, this wastewater is also super-saturated with microbes of different strains that are the main sources of total and fecal coliforms in the water body of this area. To boost up the growth of the cultured shrimps, protein-enriched artificial feed is also provided to the species. Microbial populations also increase in the pond from the decomposition of the residual feed that mainly accumulates on the pond bottom [IX], [X], [XI], [XII], [XIII], [XV].

In the present study, the lowest total coliform and fecal coliform counts were recorded during 1985 (570 MPN/100ml and 390 MPN/100ml respectively). The highest counts were observed during 2009 (Total coliform load was 1930 MPN/100ml and the fecal coliform load was 1690 MPN/100ml). The trend lines for the bacterial counts are shown in Figs. 2 and 3.
Fig 2. Predicted Total Coliform (TC) in the aquatic phase of Malancha modified extensive shrimp farm during June using Nonlinear Autoregressive Neural Network Model; real-time data from 1984 – 2019 has been used to train the model.

Fig 3. Predicted Fecal Coliform (TC) in the aquatic phase of Malancha modified extensive shrimp farm during June using Nonlinear Autoregressive Neural Network Model; real-time data from 1984 – 2019 has been used to train the model.

It is observed from the trend line that there is a sudden rise in the bacterial count during 2009, which is related to huge run-off and erosion of the embankments during this period due to Aila, a super cyclone that damaged the region severely. Possibly because of the erosion of the topsoil and embankments and churning of the

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water bodies, the microbial count during 2009 attained the peak value. Using the nonlinear autoregressive neural network model on the real-time data, the forecast reveals a total coliform load of 2075 MPN/100ml and a fecal coliform load of 1620 MPN/100ml in 2050, which is an alarming picture in terms of water quality.

The huge microbial count (total coliform and fecal coliform) in the aquatic phase of the selected shrimp farm observed, in the long run, leads us to conclude that the present method of shrimp farming is not sustainable from the ecological point of view. We suggest that providing the calculated amount of feed (based on biomass of the cultured species), regular water exchange, clearing the pond bottom sludge, and establishment of the bio-treatment pond can restore the situation and provide sustainability to shrimp farming in coastal West Bengal. As the traditional feed contains a high proportion of nitrogen, therefore we propose to apply ‘biofloc’ in the domain of shrimp farming. This can be generated by adding carbohydrates like molasses, rice bran, or tapioca. Biofloc can serve as an alternative food source for shrimps and maintain the ammonia and nitrite concentrations in shrimp pond [III] thereby reducing the microbial load.

IV. Conclusion

The shrimp farm in the Malancha area receives all the domestic and industrial wastes from the over-populated city of Kolkata. This is the possible cause of the extremely high microbial load in the shrimp farm water in terms of total coliform and fecal coliform, which can pose an adverse effect on the shrimp tissue quality. With baseline data of 36 years (1984-2019), we observe a significant hike in the total coliform and fecal coliform counts in 2050 using a nonlinear autoregressive model. Based on this output, we propose to introduce biofloc and biofloc systems to provide long-term sustainability to shrimp culture practice in this region.

Conflict of Interest:

There was no relevant conflict of interest regarding this paper.

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