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REPORT ON

SIMULATION BASED COMPARISON OF A FISH POND MODEL PARAMETERS BASED ON SYSTEM DYNAMICS VENSIM MODEL Z408

Submitted by:

Md. Shahadat Hossain, ID: 218203125
Md. Dider Hossain, ID: 218203108
Nazmus Sadat, ID: 218203123

Model Introduction

The model is mainly based on simulation to determine valuable ingredients and major constructive interlinks in a fish pond system. This model also helps to build a dynamic model that delivers appropriate details of different behaviors of variables under different management strategies. The boundary around the pond is considered as system boundary. The main inputs of the system are solar radiation, precipitation, temperature, water inflow, stocking of young fish, nutrients, organic waste, mineral fertilizer etc. And the main outputs are fish, nutrients in mud, organic substances in mud, water outflow, export of nutrients etc. This model counts algae on the basis of solar radiation and volume of nutrient in the pond. Algae is the food for fish. The dynamics of pond is characterized by mineral fertilizer inputs, organic waste inputs, young fish inputs and fish uptake for food and mud uptake for fertilization.

Human-environment interaction in fish pond model

The major human interactions that effects the overall dynamics of the model are fishing, mineral fertilizer input, organic waste input, mud removal, initial fish stocking. For example, if mud is removed, then the amount organic waste will be reduced and as a result, algae and aquatic plants will get less nutrients for their growth. If the fishing rate is high, then algae consumption rate will be reduced as well as the algal die-off rate will be increased. As a result of standard mineral fertilizer input, the availability of nutrient for the growth of algae and aquatic plants will be increased which helps to maintain the system equilibrium in the model.

Methodology and fish pond model explanation based on preset data inputs:

Preset data

Fish stocking biomass = 100 Kg/Ha

Stocking time = 10 Day

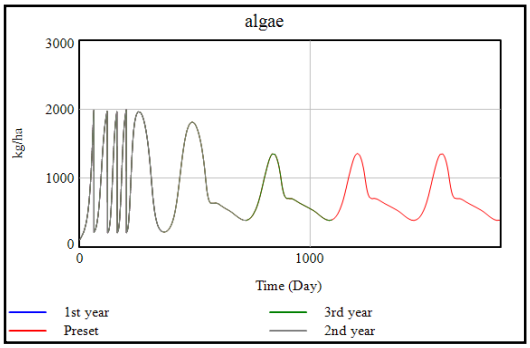
Fishing time = 3000 Day

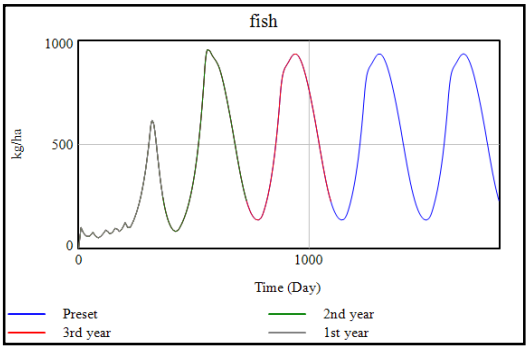
Mineral Fertilizer Input = 0

Organic waste input = 0

Mud removal = 0

The figures in the below describes the different dynamics of fish, algae, nutrient, organic waste





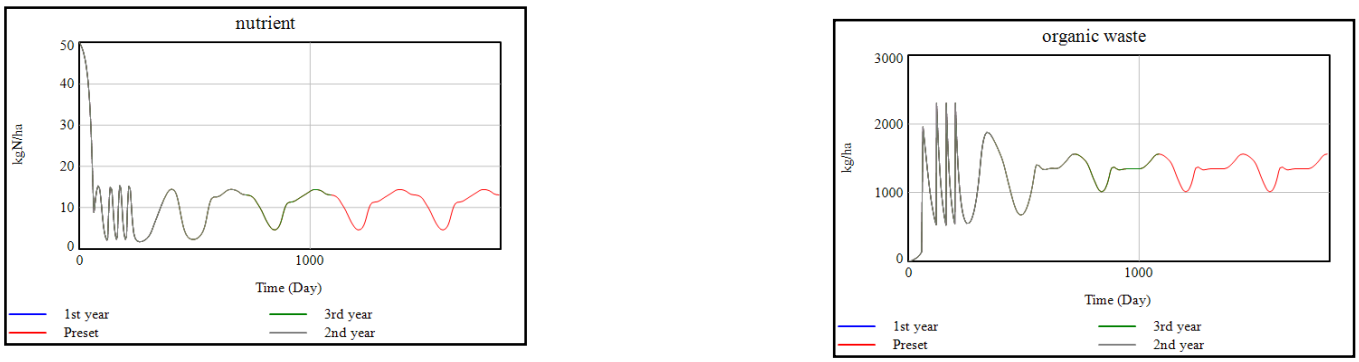


Fig 1: Dynamics of algae, fish, nutrient and organic waste based on preset data

Algae: From the figure above we can see, algae declining rate and increasing rate both are higher in the first years in comparison with the later years. It has happened due to the excessive quantity of nutrient at the primary stage of simulation period and also due to the less consumption of algae by young fish. As the time increases, the young fish becomes matured and their algal consumption rate also increases but due to the limited quantity of nutrient, the algae dynamics becomes normal.

Fish: In the initial period, the fish growth rate is impeded because of high amount of algae. As the high amount of algae consumes more oxygen which inhibit the fish growth rate. As the time passes, energy assimilated by fish due to the high algal consumption rate will be increased. This energy assimilation helps the fishes to continue their life cycle processes which is proportional to the current fish biomass. The system remains in equilibrium state because as the fish quantity increases, the algae quantity decreases. But the microorganisms converts organic wastes into nutrients. So that the algae gets enough nutrients again and their growth rate increases again. The fish stock biomass also depends on fishing time, initial algae biomass etc.

Nutrient: From the preset data, initial nutrient is given 50 Kg/Ha in the pond. In the 1st years, the nutrient amount was high because of nutrient importation from outside. But the nutrient quantity significantly decreases due to the consumption by algae. But after 1st years, there is no other source of nutrient rather than the only source which is coming from fish organic waste. These organic waste is converted into nutrient by microorganism through decomposition process that makes the system equilibrium.

Organic waste: Organic waste basically generated from fish excretions, dead algae, input of other waste like grass, vegetable, crop waste, waste from livestock and human population. In the primary stage, the quantity of algae was high because of high amount of organic waste. On the other hand, these high algal population inhibits the organic waste dynamics. Moreover, as fish become mature, they compete with algae and inhibit their growth. That's why, the amount of organic waste remains in equilibrium state in the later periods.

Results

Observed data

Day= 4000

Initial algae biomass= 150

Fish stocking biomass= 150

Fishing time= 2500 Day

Initial organic waste= 2

Initial nutrient in water= 75

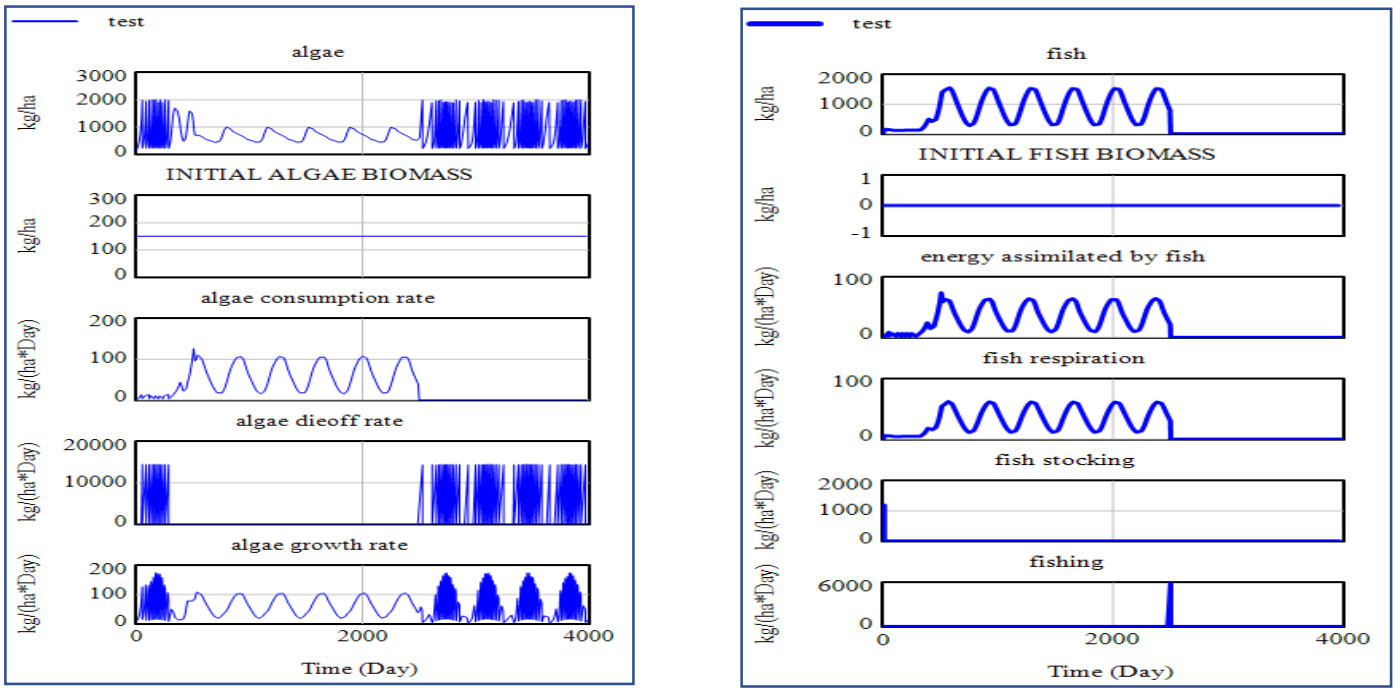


Fig 2: Dynamics of algae, fish based on observed data

Algae: The fishing was done in 2500 day but there was no new fish stocking biomass in the pond. So that on the fishing time in 2500th day, there were only matured fishes in the pond. That's why the algae consumption rate was below the lower level after 2500 day. The algae consumption rate declined because of the declination of food demand of fish and relative algae biomass. As a result of these the quantity of algae was increasing and decreasing between 2500 and 4000 days. In addition, algae die-off and growth rate was proportionally increased and decreased with total algae biomass. The algae die-off rate had rapidly increased and decreased because of the rapid declination of algae, algae density and time step. The algae growth rate had also rapidly

increased and decreased because of the rapid declination of net primary production of algae, relative algae biomass and solar radiation.

Fish: There was no new fish biomass input in comparison with the primary stage. As the fishing was done in 2500 day, the fish stocking was below the lower level between 2500 and 4000 day. The fish stocking had declined due to the declination of the stocking of young fish. The fishing mainly depends on fish, fishing time and time step. But after 2500 day, energy assimilated by fish had declined. The energy assimilated by fish had declined because of the declination of the algae consumption rate and energy assimilation efficiency. That's why the fish respiration had also declined between 2500 and 4000 day due to less energy of fish. The fish respiration had also declined because of the declination of the fish and specific respiration fish. So due to the fishing, the declination of fish stocking, energy and respiration, the amount of fish had declined below the lower level between 2500 and 4000 day rapidly.

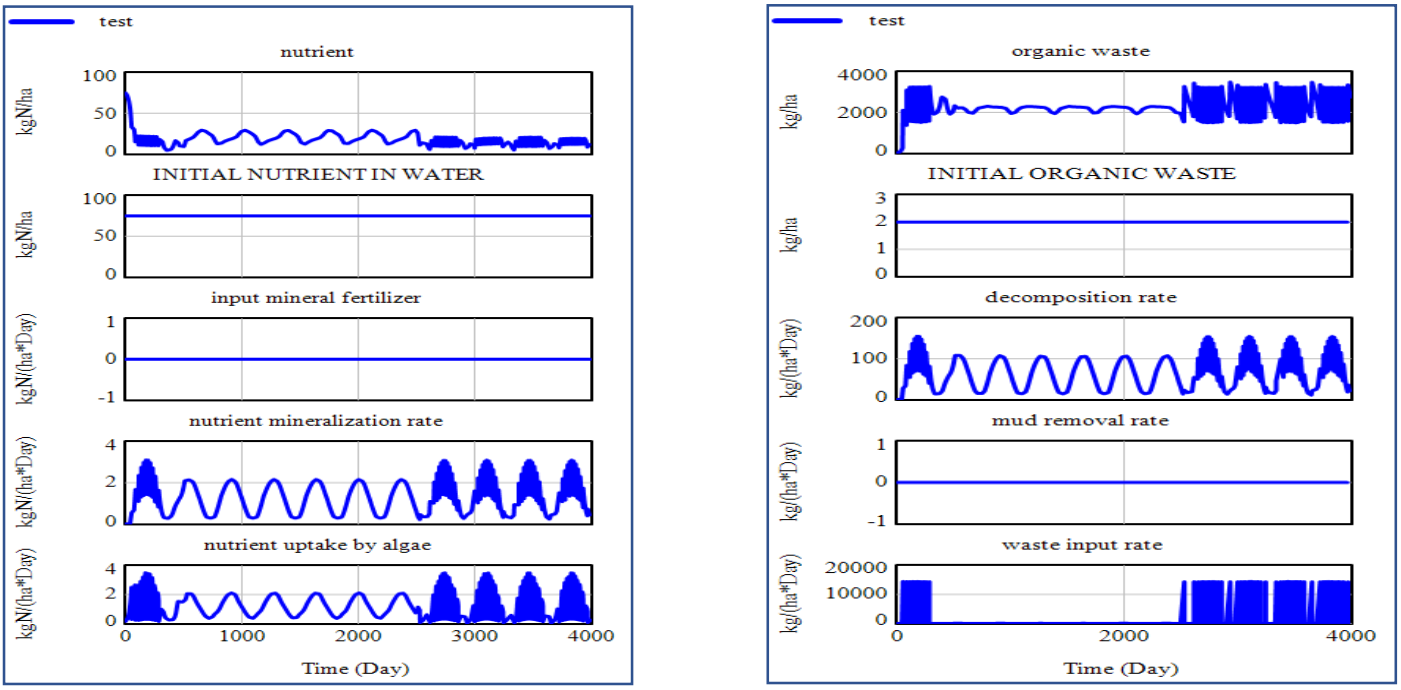


Fig 3: Dynamics of nutrient and organic waste based on observed data

Nutrient: There was no new initial nutrient in water in comparison with the primary stage. The input mineral fertilizer had no change in the observed data. The input mineral fertilizer mainly depends on days per year input and mineral fertilizer input. There was declination in nutrient amount because nutrient uptake by algae was high between 2500 and 4000 day. The nutrient uptake by algae was high because of the high increase in the algae growth rate and specific nutrient content of algae. So there was also eutrophic condition occurred because of the high algal blooms. In the fish pond, high algal blooms occurred because of the input of high amount of mineral fertilizer. On that case, standard amount of mud removal rate had declined the standard

amount of algal blooms. The amount of nutrient was also low between 2500 and 4000 day because of the high increase in nutrient mineralization rate. The nutrient mineralization rate was high because of the high increase of decomposition rate and specific nutrient content of organic waste between 2500 and 4000 day. As there was declination in the nutrient amount between 2500 and 4000 day, there was oligotrophic condition occurred. As the oligotrophic condition occurred, the fish population had gone down due to lack of nutrients. After the standard amount of mineral fertilizer input, there was standard increase in fish population.

Organic waste: There was no new initial organic waste input in comparison with the primary stage. The amount of organic waste had rapidly increased and decreased between 2500 and 4000 day because there was rapid increase and decrease in waste input rate on that time. The waste input rate had increased and decreased rapidly because days per year waste input rate, algal die-off rate, organic waste input, organic waste of fish had increased and decreased rapidly. Between 2500 and 4000 day, amount of organic waste had increased and decreased rapidly because of the decomposition rate had increased and decreased on that time. The decomposition rate had increased and decreased because of the increase and decrease of the organic waste, normal organic waste decomposition rate, temperature effect on decomposition. Also the mud removal rate mainly depended on the days per year removal rate and mud removal.

Discussion

By using system dynamics model in case of fish pond, we actually know the important elements and structural connection in the fish pond system. From this model, we also know about the dynamic behavior of different kind of state variables of the fish pond through different kinds of management strategies. Since from this fish pond model we get better understanding of the dynamics of the fish pond and their response to management inputs though there was no particular time development for a specific ponds. Overall fish pond model fill up the main criteria to develop this model. As fishing time increased to 2500 day, we observed that there was significant change in the algae growth and die-off rate which causes algal blooms in the fish pond model and spoil the whole system dynamic equilibrium. This problem can be solved by specific amount of mud removal rate which brings the system in previous equilibrium. On the other hand, the change of the initial algae biomass, the initial stock of young fish does not influence the system dynamic behavior. The consideration of water inflow and outflow was missing in the model which could be added in the fish pond model.