Minimizing the Factors Leading to Eutrophication in Lakes

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Abstract: ***Lakes in today's generation are losing their inhabitants – fish, plants, microbes and many other species which thrive in the freshwater body. This has occurred due to continuous abuse of the water bodies by industries and civilians alike. Sewage and waste water are pumped into lakes with little or no concerns about its effect on marine life and subsequently on us human beings. Some lakes have been affected to the point of total destruction of life by the process called eutrophication. This is caused by the seepage or running-off of fertilizers. Controlling this underground is a tough task and hence it is a better option to remove such chemicals from the lake waters. Currently the only purification is done at some places in sewage treatment plants. Thus it was decided to use a device that will be positioned somewhere in the middle of the lake. This will run a pump which shall circulate water through the device. The device consists of barrel-like structures along which are specific filters and chemicals which shall remove the impurities from the water. It also consists of the suction fan responsible for creating the current of water. As the water enters into the device a mesh prevents the entry of particulate matter and small fish into the device thus reducing harm to the device. The device shall be targeting the chemicals required for the production of harmful quantities of algae and the few other harmful chemicals that seep into the water like pesticides. Keeping in mind the presence of aquatic life there are arrangements so that they do not get caught up in the currents generated by the device. The device operates using a low powered energy source and it is required to change the used filters periodically. This is economical in the long run as the maintenance costs and frequency reduces over time as the polluting chemical concentrations reduce. This process aims to prevent further deterioration of lake water and will restore the balance of the aquatic ecosystem.***

Keywords: Filter, Eutrophication, Suction pump

1. Introduction

Lake water is one of the very few sources of freshwater on the surface of the earth. This is taken for granted in most places. Thus, lakes are used as a dumping ground for liquid wastes from industrial, agricultural and civilian sources. Among these wastes do chemicals which affect the wildlife inhabit the lake. Some of these chemicals support the formation of algal bodies quickly. The quicker the algae grow the quicker they reproduce. Thus, lead to algal blooms. When these algal blooms die consume a huge amount of oxygen to decompose. This shortage of oxygen leads to large scale death of oxygen-dependent organisms. Also, the chemicals hamper the growth of aquatic plants and supports microorganism growth. This leads to a state where no life other than surface microorganism thrives. Eutrophication depends mainly upon these chemical contents:

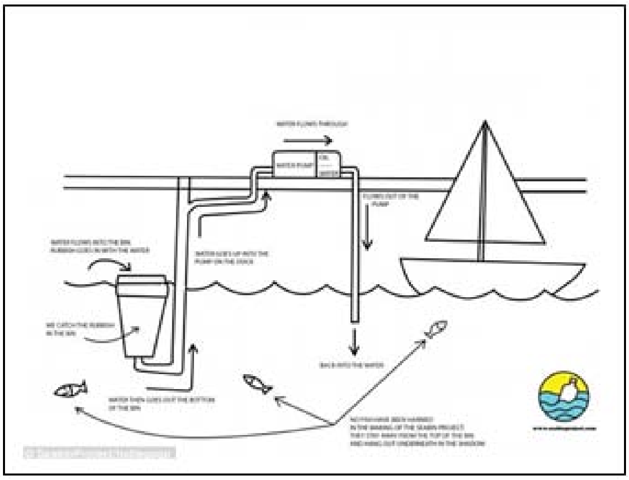
- Phosphates – from agricultural run-offs
- Nitrites – from sewage wastes

These chemicals must be removed from the water to prevent further production of such harmful microorganisms. To do this a device was designed which efficiently absorbs these chemicals by creating a circulating stream of lake water using a pump.

2. Existing Technologies

A look into the existing attempts at similar endeavors led to the Sea-Bin. This is a device which when dropped into water sucks it into the center and cleans all kinds of particulate matter and solid wastes.

The Sea-Bin has a pump on shore which pulls water from the bottom of a bin dropped in the dirty water body. This in turn sucks water from around the top of the bin into it. The bin holds a net which captures all solid wastes from the water body. The net is changed from time to time when it becomes full. Having the suction from the top doesn't risk marine life.



The Sea-Bin is capable of removing only solid wastes from the water it is placed in. With a device like that in place, the need to removed dissolved chemicals remains.

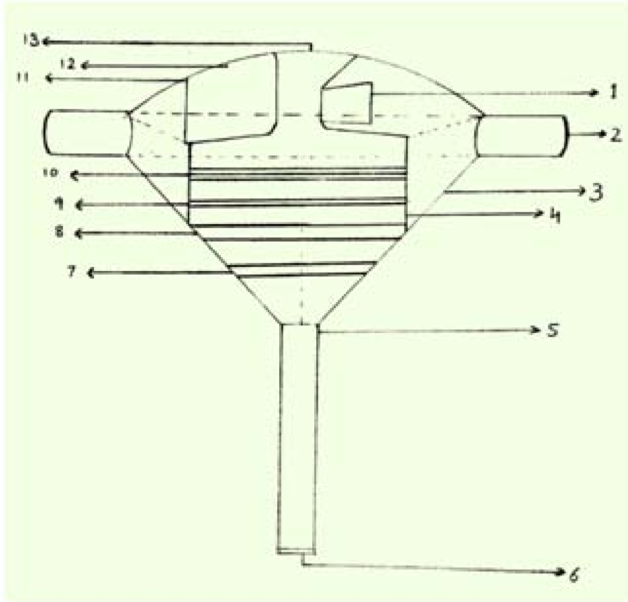
3. Design

The device has a main container body which holds all chemicals and sieves for the cleansing of water. It is a cylindrical body with a conical base. A hole at the extreme bottom connects with a pipe. This pipe extends about 9 meters below the container and has diameter of 8 cm. It has a rustproof sieve at its end which doesn't allow the entry of fish and particulate matter. The pipe leads to the container in the cylindrical body. The container is about another meter thus making the total length of the device 10 meters. The diameter of the container is 1 meter. This container holds all layers for neutralization of the chemicals. The container has four layers. Each layer has a reagent encased in a fine sieve so that it doesn't move. Above this is a narrower pipe which has a pump. This pump is responsible for sucking the water up from the lower portions of the pipe and out from the outlet located above. The pump creates a flow of water with a volume rate of 1.5 lit/sec. The reason for keeping the inlet some distance below the surface of the water is that the water below contains a little more concentration of the chemicals to be removed which settle down due to weight. The gross weight of the device is estimated to be from 15 to 18 kilograms with the reagent layers weighing around 8 kilograms. This weight is held up by the help of a circular float.

The device requires a power supply for the working of the pump. This power supply can be provided from the shore or can be provided using an on-board battery. If the device is close to the shore, the supply should be taken from the shore. The reason for this is that the battery drains quicker than the chemicals situated in the container. Thus, the device will need more frequent servicing to change the battery. Also a battery can be risky during mishaps in the water. The leaking of battery chemicals will do serious damage to the ecosystem we are trying to protect. The device sucks up water and removes the chemicals while taking the water up to the surface. This process continued repeatedly over a period of time removes the unwanted chemicals.

A. Parts of Construction

1. Pump – Motor assembly
2. Float
3. Main body
4. Container
5. Pipe
6. Inlet with sieve
7. Phosphate Filter (Lime)
8. Activated Carbon Layer
9. Micro-sieve
10. Deionizer
11. Dome-shaped Lid
12. Storage compartment for battery
13. Outlet



B. Working

The device sucks in water from point 6 – the lower end of the pipe. This is fitted with a 325 U.S. grade sieve which allows only particles less than 44 microns to enter. This sieve prevents the entry of aquatic life and dirt particles into the container. The water then enters the container at point 5 and encounters the phosphate filter.

The phosphate filter (7) consists of a layer of lime. This layer reacts with the organic phosphates present in the water to release a calcium salt. Thus, organic phosphate is turned into inorganic (ionic) phosphate. The water now becomes ionized and heads toward the next filter. But, this introduces another harmful component i.e. calcium ions. These calcium ions can be harmful to aquatic life if released.

The next filter is a mesh of activated carbon (8). This carbon adsorbs chlorines, chloramines and organic matter. Along with adsorbing these chemicals, the carbon layer gives out minute strands called 'fines'. These 'fines' are then collected on the micro-sieve (9) located next along the stream of water. The water leaving this filter is rich in calcium and clean of most harmful organic compounds. However, this layer also removes a natural disinfectant – Chlorine. Thus, the area above the carbon layer is susceptible to garner bacteria growth.

After the carbon filter, the water goes through a layer called the deionizing layer. This layer has two kinds of resins – cationic and anionic resins, each having their own sub-layer. The water first encounters the cationic resin which replaces all calcium ions for H^+ ions. Then the water enters the anionic sub-layer. Here, the phosphate ions are replaced for OH^- ions. Thus, both harmful ions i.e. calcium and phosphate ions, are removed from the water.

After the water has passed through all these layers it is given back outside through the outlet given on top. The water exiting the device forms a thin layer on the top most surface of the device. Here, the ultra-violet radiations from the sun can kill the bacteria formed after the activated carbon layer. Thus, keeping the device from promoting the growth of any harmful bacteria.

During the operation of the device it consumes the reagents present in the various layers over time and loses effectiveness. Thus, it is required to have a regular maintenance done in which the reagents are switched for fresh layers. This ensures proper working of the device for the duration it is kept in the water. During the maintenance, the different layers along with the battery can be accessed by lifting the dome-shaped lid (11) of the device. After every service the device is capable of running for 2 to 3 months without any further servicing.

4. Chemical Reactions

The following chemical reactions take place in the presence of sunlight for production of algal bodies:

$16NH_4^+ + 92CO_2 + 92H_20 + 14HCO_3^- + HPO_4^{2-} \rightarrow C_{106}H_{263}O_{110}N_{16}P + 106O_2$.

$16NH_4^+ + 124CO_2 + 140H_20 + 14HCO_3^- + HPO_4^{2-} \rightarrow C_{106}H_{263}O_{110}N_{16}P + 138O_2 + 18HCO_3^-$.

The device has the following reactions taking place in their respective layers:

Layer 1: Phosphate filter (Lime)

$10Ca^{2+} + 6PO_4^{3-} + 2OH^- \leftrightarrow Ca_{10}(PO_4).6(OH)_2\downarrow$

Layer 2: Activated Carbon

Adsorption occurs at this layer. Chlorines and Chloramines get adsorbed on the A.C. mesh.

Layer 3: Deionizer

Cationic resin reacts with cations to release H+ ions. Then, Anionic resin reacts with the remaining phosphate anions to release OH^- ions.

5. Calculations

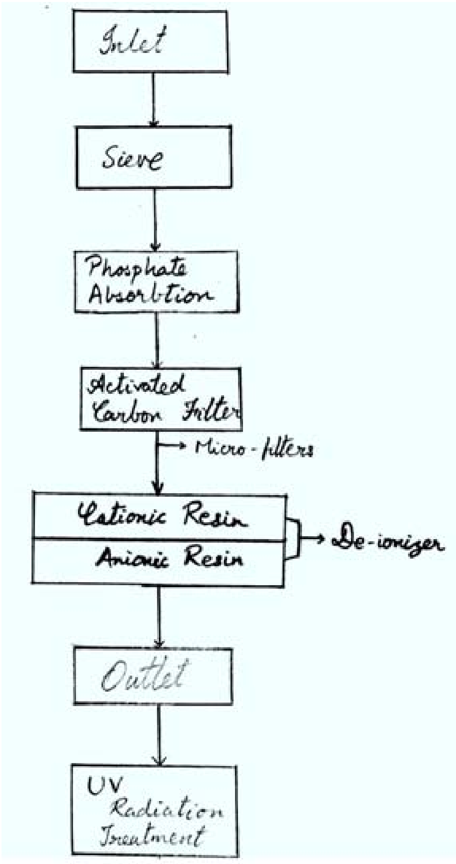
The following data are assumed for the device:

Water flow rate = 1.5 lit/sec = 1.5×10^{-3} m^3/sec
Density of water = 1000 kg/m^3
Diameter of pipe = 8 cm = 0.08 m
Head of water above pump = 0.5 m

We have an equation for theoretical power required for pumping action as:

$P_{th} = \rho \times g \times Q \times H$
ρ is the density of water.
g is the acceleration due to gravity.
Q is the volume flow rate of water through the pump.
H is the total head in the pipe. It is the sum of static head and dynamic head of water.

Thus, the theoretical power after substituting the values is found to be 140 watts. However, a real pump has lower efficiency than an ideal one. Assuming the efficiency of the pump to be 60 % we can calculate the power required for the device to operate and can supply power accordingly. By this we get the value the requirement as 240 watts.



6. Conclusion

The device works by sucking in water and passing them over layers of meshed reagents to clean the lake water of the harmful phosphates and organic matter which lead to eutrophication. With increasing use of fertilizers across agricultural fields, the increase of chemical run-off is eminent. The need for devices such as these is on the rise and this is but a small step. This device hopes to reduce environment problems in lakes and other small freshwater bodies. This device also aims to propagate the idea of clearing chemicals after they have been introduced to the water body so that the water body can be maintained.

Acknowledgment

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