Treatability studies for nutrient removal using marble powder to restore Kukkarahalli lake and Lingambudi lake of Mysuru city

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Abstract: *Water is an essential natural resource for the existence of life on this earth. Increase in Human activities have resulted in deterioration of various water bodies, especially the lakes and ponds. Lakes in an urban region adds to the scenic beauty and provides recreational activities. Eutrophication of lakes is increasing day by day due to overload of nutrients in water body which make unfit for use. Hence restoration is required. Present study is one such attempt for the improving the water quality of two lakes of Mysuru city i.e. Kukkarahalli lake and Lingambudi lake. Marble powder was used in the present study which was added to lake water sample. The measured water quality parameters are pH, total alkalinity, total hardness, nitrate and phosphate. The results achieved for those parameters were within the drinking water standards. Phosphate removal was achieved was up to 50% at a dosage of marble powder being 150mg/L for Kukkarahalli lake water and 100 mg/L for Lingambudhi lake water at a contact time of 20 and 30 minutes.*

Keywords: Lake, eutrophication, restoration, marble powder, nutrients

1. Introduction

Lakes are an inland bodies of water located within a depression of land surface. They provide utility service for people surrounding the area, recreational activity and also is of aesthetical importance. In additional to this lakes are of ecological and environmental importance too since they store water and thereby help in regulating the runoff volume and limit the effect of floods. In order to achieve these services from lake it must be restricted from the entry of wastewater from surrounding industries, sewage from residential areas etc. but now a days due to anthropogenic activities the water bodies have been polluted and has become a dumping site. The entry of nutrients mainly phosphate and nitrate in lakes leads to the growth of plant biomass (algae) which in turn leads eutrophication. Eutrophication can be defined as enrichment of nutrients in water bodies which leads the growth of algae. Due to eutrophication the geochemical cycle will alter. Both human and animal population will have a harmful effect on health when surrounded by eutrophication environment, especially when water undergone eutrophication is drawn for drinking purpose. Eutrophication results in altering various physico-chemical parameters of water body. The water becomes highly alkaline. Hence in order to mitigate these problems restoration of lakes is necessary.one such method is chemical method which includes liming of lakes. Liming can be done using calcium carbonate, oxides of calcium or calcium hydroxide. Liming is done because it is inexpensive, easily accessible and adsorption of phosphate is greatly achieved. In the present study marble powder is used as an alternate for

lime. India produces for about 7 million tonnes of waste is generated in the form of powdered marble. This powder is usually dumped in the landfill site which generally causes environmental problems. Due to dumping of marble powder porosity and permeability of the top soil is reduced, it causes respiratory problems for nearby residential area, it also effects on landscape beauty of the area, and the growth of crops is limited. Hence there is a need for mitigating these problems. Therefore marble powder can be used as an alternate to lime since it is rich in calcium carbonate content and hence improve the water quality and improve the ecological balance.

3. Material and methodology

The heritage city Mysuru is one of the popular city in Karnataka state, India. It lies between co –ordinates 11º 39' and 12º 50' north latitude and 75º 45' and 77º 45' east longitude. Mysuru city is consisting of several water bodies both large and small. It consists of several lakes like Kukkarahalli lake, Lingambudi lake, Dalvoy lake, Devanoor Lake, Karanji Lake and many more which adds to the scenic beauty of the city.

Kukkarahalli Lake is located on the heart of the Mysuru city connecting the Manasagangotri, the Kalamandir and the central food technological research institute campus. The lake covers a catchment area of more than 414 square kilometres. The water body spreads over 62 hectares.

Lingambudi Lake is located on the south western region of the city which is nearby to Dhattaghalli layout. The lake is the largest of all covering the major portion of western region of the city. The geographical area slopes from north to south having an average slope varying 5 % to 10 %. The total catchment area is about 4400 hectares. The total number of drains are 16 having a drain length of 35 km.

(a)

(b)

Fig 1 Sampling points a) Lingambudi lake b) Kukkarahalli lake

2.2 Marble powder

In the present study black marble powder was used for the removal of nutrients and other water quality parameters. Marble is a non-foliated metamorphic rock composed of recrystallized carbonate minerals. The recrystallization of limestone at intense pressure and heat of geologic processes results in formation of marble. Marble primarily consists of mineral calcite ($CaCO_3$) and other minerals like clay mineral, mica, silica, iron oxide. They are commonly called as
Calcite. Marble is simiar to lime but differ in the structure and porosity. Marble has many decorative and structural uses which includes construction of exterior wall, flooring, stairways and walkways but in the preaent study marble powder is used aas an agent for improving the water quality of water bodies. Chlorides, nitrates, sulphates and other chemical compunds react differently with marble and reduce nutrient level.

2.3 jar test analysis

1 to find optimum dosage and contact time

Jar test analysis was conducted in the laboratory to identify the optimal dose and the contact time for the nutrient removal from lake water samples. The initial characteristics of various physico chemical parameters was analysed before the start of experiment. Six jars were used in which each contained a litre of lake water sample. To each jar the dosage of marble powder was varied from 50,
100, 150, 200, 250 and 300 mg/l. At the beginning the samples were mixed for 5min at 100 RPM and
then followed by 20min at 40 RPM. Samples were allowed to settle for about 30min and later was analysed for various physico- chemical parameters. Similarly jar test was conducted to find the optimum contact time. The RPM was set to 60 and the dosage
Obtained was applied to all the six jars. At the time interval of 10min and upto 50 min water sample was analysed and thus optimum contact time was fixed

3 Results and discussions

Table 2 characteristics of water quality of the two lakes

Parameters	Kukkarahalli lake	Lingambudi lake
pH	9.04-9.34	8.5-9.11
Conductivity(µs/cm)	350-380	760-800
Chlorides(mg/l)	74-105	75-110
Total alkalinity(mg/l)	240-300	300-340
Total hardness(mg/l)	264-340	280-400
Phosphate(mg/l)	7-15	6-10
Nitrate(mg/l)	4-8	6-9

3.1. Batch Studies to Find Optimum Buffer Dosage

Hydrolysis reaction of calcite: Marble powder is nothing but calcium carbonate since marble consists 90% of calcium carbonate crystals in it. For pH>8 cationic species, such as Ca_2^+, $CaHCO_3^+$ and $CaOH^+$ rendering the mineral surface positively charged. For pH > 8, negative species prevail but concentration of the positive species is considered and is dominant.

$\rightarrow$ $CaCO_3$ $Ca_2+ + CO_3^{2-}$

$\rightarrow$ $CO_3^{2-} + H_2O$ $HCO_3^- + OH^-$

$\rightarrow$ $Ca^{2+} + HCO_3^-$ $CaHCO_3$

$\rightarrow$ $Ca^{2+} + OH^-$ $CaOH^+$

(Source: Ghazy et.al and Karageorgiou et.al)

When marble powder (calcium carbonate) is added to water at higher pH (basic condition) Calcium hydroxide form an aggregate structure which is proposed to have involved in the removal of various water quality parameters in this study. Calcium hydroxide surface is positive charge or electron deficient species which induces electrostatic force of attraction with negative ions.

$$CaCO_3 + H_2O = CaHO^+ + H_2CO_3$$

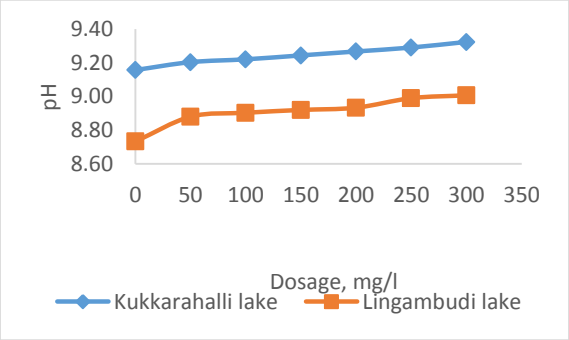
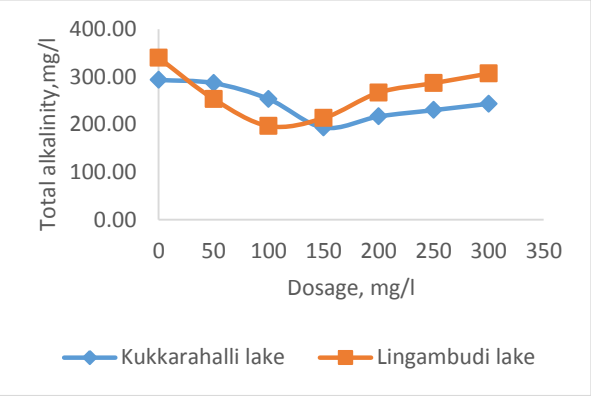
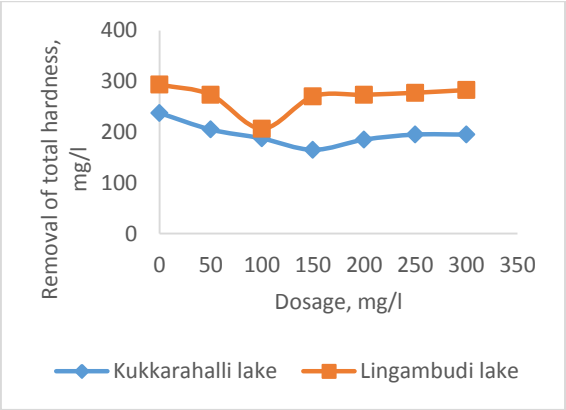


Figure 2: pH variation of marble powder

The addition of marble powder to both the lake water did not impact much on the pH. There was a slight increase in the pH value this is due to the basic nature of marble powder.



(a)



(b)

Figure 3: Total alkalinity and total hardness variation with marble powder

Alkalinity in water is due to carbonates, bicarbonates and hydroxides ions. Hardness in water is due presence of ions of calcium and magnesium. These ions gets adhere on the surface of $CaOH^+$ formed on addition of marble powder. Hence powder, at the beginning there is decrease in concentration and then increase but this is up to 150 mg/L and 100 mg/L as in case of Kukkarahalli lake water and Lingambudi lake water. After these concentration the surface availability for adhering will increase and hence more decrease in not seen.

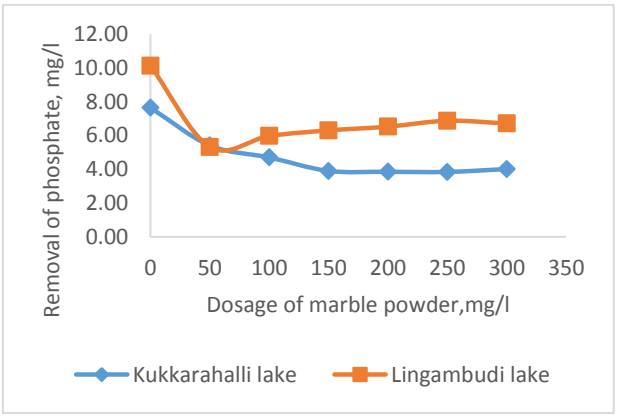


Figure 4: phosphate variation with marble powder

When pH exceeds 9 calcite sorbs phosphorous very well. Hence in fig 4. The removal of phosphorus is achieved about 41% (Kukkarahalli Lake) and about 50% (Lingambudi Lake) with the precipitation of hydroxyapatite.

$$10\ CaCO_3 + 6\ HPO_4^{2} + 2\ H_2O \longrightarrow Ca_{10}(PO_4)_6(OH)_2 + 10\ HCO_3$$

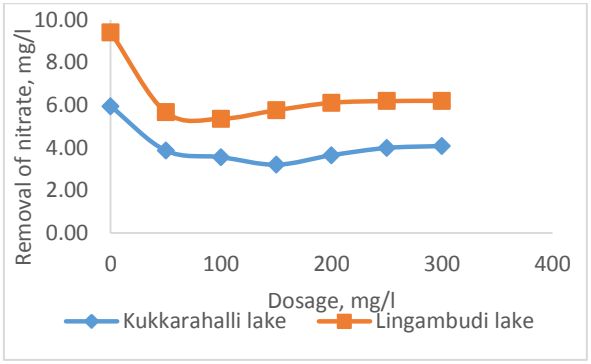


Figure 5: Nitrate variation for marble powder

Nitrogen in water will in three forms i.e. nitrate-nitrogen, nitrite- nitrogen, and ammonical- nitrogen. When marble powder ($CaCO_3$) is added the negative ions adsorbs on the hydroxide surface to have the maximum removal up to 150 mg/l (Kukkarahalli lake) and 100mg/l (Lingambudi lake).Since nitrate is a heavy metal ion after 150 mg/l and 100 mg/l the ions do not bind on the surface further and hence there is an attainment of equilibrium. The maximum removal is attained for about 50%.

3.2 Variation in contact time for obtained dosage

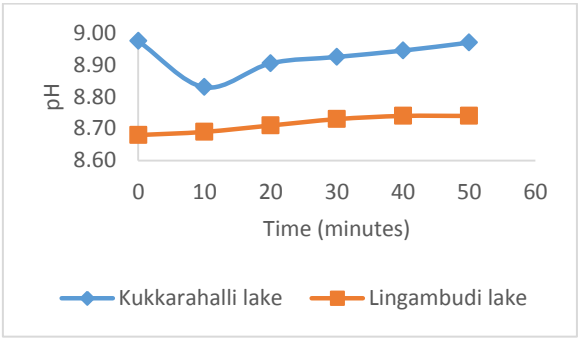


Figure 6: Effect on pH for varying contact time

Optimum dosage of marble powder: 1) Kukkarahalli lake- 150 mg/L 2) Lingambudi lake-100mg/l

At the 0^{th} minute the pH was 8.68 and 8.98 for the lake water sample of Kukkarahalli and Lingambudi. Later as the contact time between the water and the applied dosage of marble powder increased the pH also increased

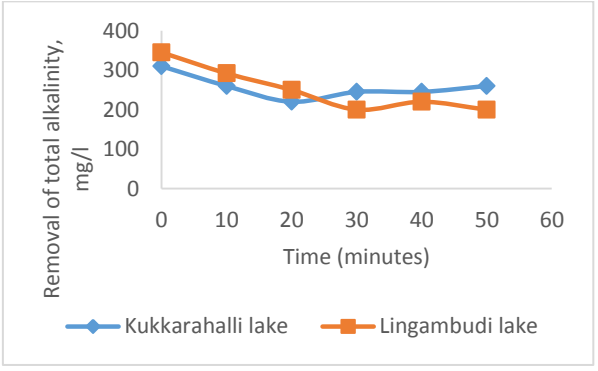


Figure 7: Effect on total alkalinity for varying contact time

Optimum dosage of marble powder: 1) Kukkarahalli lake- 150 mg/L 2) Lingambudi lake-100mg/l

The concentration of total alkalinity deceased the contact time decreased and later an equilibrium was achieved. At 20 minutes the maximum removal was achieved for lake water sample of Kukkarahalli Lake and 30 minute optimum contact time was achieved for water sample of Lingambudi Lake.

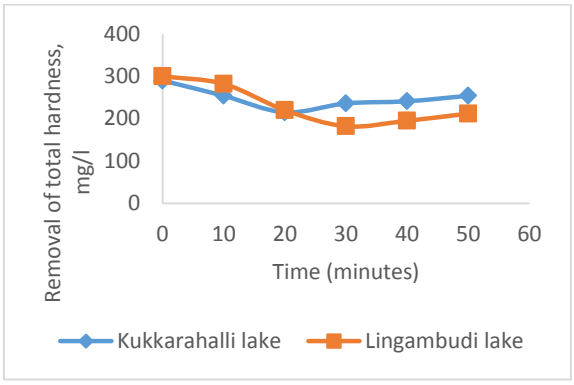


Figure 8: Effect on total hardness removal for varying contact time

Optimum dosage of marble powder: 1) Kukkarahalli lake- 150 mg/L 2) Lingambudi lake-100mg/l

Total hardness removal concentration was achieved maximum at a contact time of 20minutes and 30 minute for water sample of Kukkarahalli Lake and Lingambudi Lake, initial concentration being 300mg/ L.

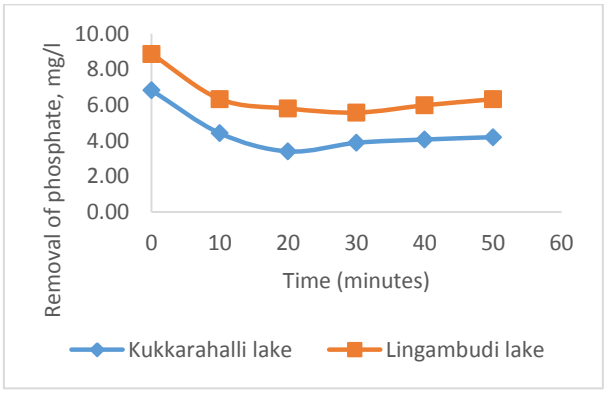


Figure 9: Effect on phosphate removal for varying contact time

Optimum dosage of marble powder: 1) Kukkarahalli lake- 150 mg/L 2) Lingambudi lake-100mg/l

From fig it's clear that phosphate removal concentration is maximum at a contact period of 20minute. Phosphate adhere on the surface of marble powder and hence concentration reduces but due to the valence of phosphate being more it does not leaves the surface so easily and hence equilibrium is achieved at early stage removal efficiency being about 40%-50%.

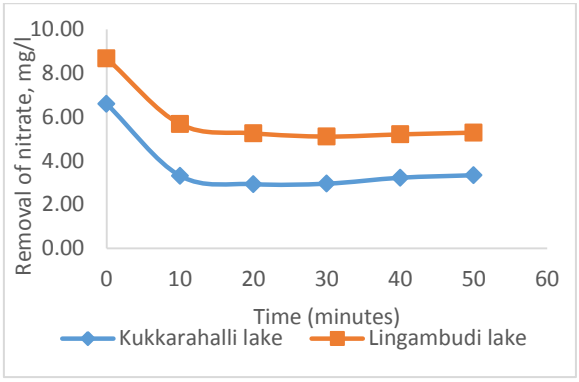


Figure 10: Effect on nitrate removal for varying contact time

Optimum dosage of marble powder: 1) Kukkarahalli lake- 150 mg/L 2) Lingambudi lake-100mg/L

After 10minutes of contact time of water sample with marble powder, gradually there is an attainment of equilibrium. Hence at 10minutes maximum removal efficiency is obtained and thus 20minutes being optimum contact time.

4. Conclusion

From the physico-chemical analysis conducted it is clear that the water is highly polluted with excess nutrient content. From the experiment conducted at lab scale, the addition of marble powder enhanced in the removal of concentration of various parameters and thus improving water quality. The optimum dosage and contact time obtained for Kukkarahalli lake water sample was 150mg/L at 20minutes contact time whereas for Lingambudi lake it was 100mg/L at 30minutes contact time. The concentration of total alkalinity, total hardness obtained for the optimum dosage matched the drinking water standards. Even phosphate and nitrate concentration was reduced upto 50%. Hence the utilization of marble powder which is obtained during sawing and cutting process in the marble industry can be done for the improving water quality.

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