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A Study On Nutrient Removal For Kukkarahalli Lake Of Mysuru City Using Marble Powder

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Abstract

The present study is about the application of marble powder into lakes for the removal of nutrients from it. Kukkarahalli Lake of Mysuru in which water quality has been deteriorating was selected for the present study. To study about the physico – chemical characteristics of the lake, water quality analysis was carried out for a period of time. Waste marble powder generated during cutting and sawing of marble was used for the study. Black marble powder was brought from Nanjangudu industrial area. This marble powder was applied to the lake water and jar test with varying dosage of it was conducted in the laboratory and also the contact time required for maximum removal of nutrients was also carried out. For comparison of marble powder with other adsorbents used for water quality improvement, alum was used. Same procedure was followed as in case of marble powder wherein marble powder proved to be better consuming less dosage for maximum removal. Overall from this study it can be inferred that even marble powder can be used for the improvement in water quality, rather than dumping it in landfill site and causing environmental pollution and causing ecological imbalance.

Keywords: *Marble powder, Adsorbent, Jar test, Nutrient Removal*

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INTRODUCTION

Water is important natural resources for the existence of life and also it adds to the economic and social development. The anthropogenic activities is weakening the water quality and also disturbing the aquatic ecosystem. The use of water for various purposes by human is arising a problem of depletion of water supply to lakes, rivers, estuaries and wetland and there is a growing concern whether this depletion is enough for the healthy functioning of ecosystem.

Marble processing industries generates around 7 million tonnes and this being one of the major solid waste causing environmental problems. Marble waste is produced during sawing and polishing processes.

Phosphorus is an essential nutrient for all forms of life and cannot be replaced by other species. In order to reduce the negative effects of overloading the ecosystems with phosphorus, it is necessary to investigate various techniques and materials that could contribute to removal. Marble powder as sorbent material can be used in the removal of phosphorus and other nutrients and heavy metals from water.

The main objective of the proposed research is to carryout studies for the improvement of the buffering capacities of selected lakes of Mysuru city.

MATERIALS AND METHODOLOGY

Materials

Marble powder

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 CaCO3 and other minerals like clay mineral, mica, silica, iron oxide. They are commonly called as calcite. Marble is similar to lime stone but differ in the structure and porosity. Marble has many decorative and structural uses which include construction of exterior wall, flooring, stairways, and walkways.

Likewise in this study black marble powder obtained from Nanjangud Industrial area during cutting and sawing of marble stone is used for the removal of nutrients from lake water. Chlorides, nitrates, sulphates and other chemical compounds react differently with marble and produce various by-products. **See Figure: 1**

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The black marble powder collected was analysed for EDS. **Figure 2 and Table 1** represents the EDS analysis results for black marble powder. From this it can be noted that silica, oxygen and calcium are present in huge quantity. This calcium content present in marble powder helps in the reduction of concentration of various parameters in the present study.



Figure.1 (EDS) for marble powder

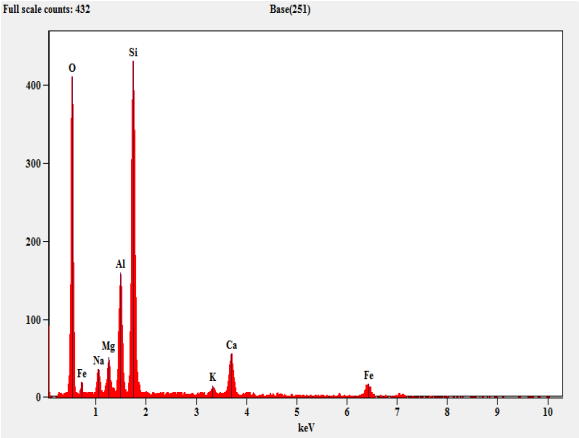


Figure.2 EDS analysis for black marble powder

Table 1 Elemental distribution percentage of marble powder

Element	Weight in percentage
Oxygen	50.50
Sodium	3.97
Magnesium	2.52
Aluminium	7.43
Silica	23.11
Potassium	0.98
Calcium	4.95
Iron	6.55
Total	100

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Methodology:

Jar Test Analysis

a) To find the optimum dosage

Jar test analysis was conducted in the laboratory to identify the optimal dose for the improvement of buffering of lake. 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 were analyzed for various physico- chemical parameters.

b) To find the optimum contact time

Jar test analysis was conducted in the laboratory to identify optimum contact time required for the improving the buffering capacity of lake. Before the experiment was started the initial characteristic of various physico chemical parameters was analyzed. Six jars were used filled with a litre of lake water sample. 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 analyzed and thus optimum contact time was fixed.

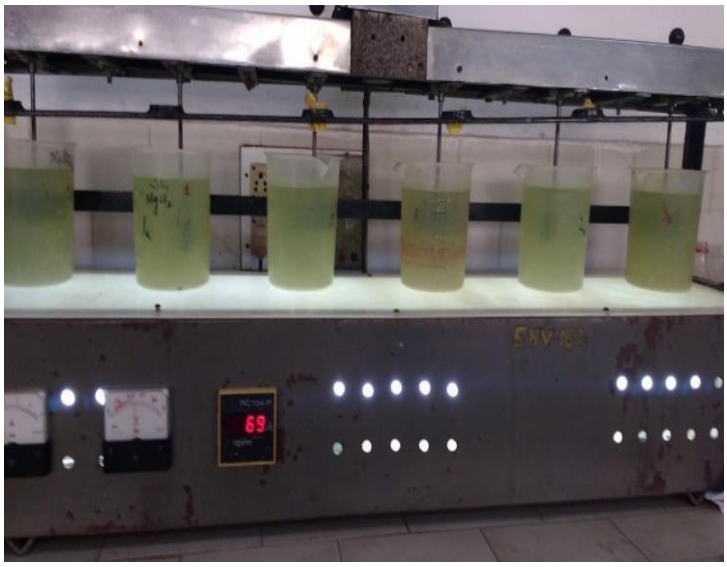


Figure.3 Stabilization period of lake water with addition of marble powder

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To study the stabilization period of lake water, 10 jars were used. This study was carried out twice one for Kukkarahalli lake water sample and the other for Lingambudi lake water. Each of the jar was filled with one litre of respective lake water sample. To this sample of water the optimum dosage of buffer obtained from both the lakes was sprinkled in all the jars. The initial characteristic of various parameters was measured. Each day analysis of various physico chemical parameters like pH, total alkalinity, total hardness, chloride, phosphate and nitrate were determined the stabilization period was determined.

RESULTS AND DISCUSSION

General

In this chapter, lake water quality analysis, optimum dosage and optimum contact of marble powder has been analysed for the study area, Kukkarahalli Lake. The experiments were conducted in three trials and the average of it has been plotted.

From the table it's clear that all the parameters are exceeding the standard limit. In addition to this the presence of algae and high nutrient content in the water, the lake is considered to be eutrophic.

Table.2 Characteristics of physico- chemical parameters of Kukkarahalli Lake

Parameters	Kukkarahalli lake
pH	9.04-9.34
Conductivity(µs/cm)	350-380
Chlorides(mg/l)	74-105
Total alkalinity(mg/l)	240-300
Total hardness(mg/l)	264-340
Phosphate(mg/l)	7-15
Nitrate(mg/l)	4-8

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Batch Studies to Find Optimum Dosage

a) Variation in pH

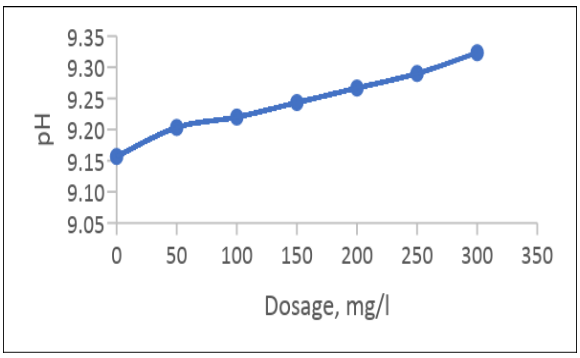


Figure 4: pH as a function of marble powder

From figure 4 it's clear that as the dosage of marble powder increases pH also increases. This increase is due to marble powder being basic in nature and also due to release of carbonic acid.

b) Variation in Total Alkalinity

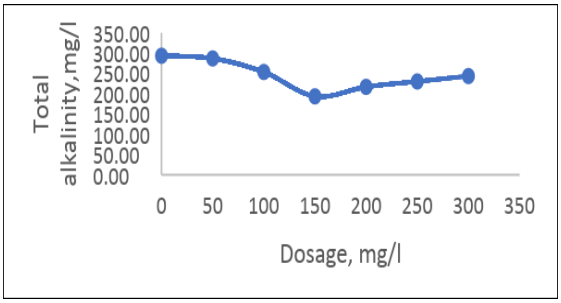


Figure 5: Total alkalinity as a function of marble powder

The addition of marble powder to water sample influence on the total alkalinity of the water. Alkalinity in water is due to hydroxide, carbonate and bicarbonate ions. When marble powder is added to lake water at varying dosages (50 to 300mg/l), at beginning the concentration of total alkalinity is decreasing and further increasing gradually. The free carbonate and bicarbonate ions having negative ligands interact with positive surface and sorbs on it. Further at higher dosage i.e. 200 mg/l the negative ions compete for surface and hence sorption decreases and much removal is not noticed. The total alkalinity concentration reduced from 350mg/l to 200mg/l (35 – 38 %).

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c) Variation in Total hardness

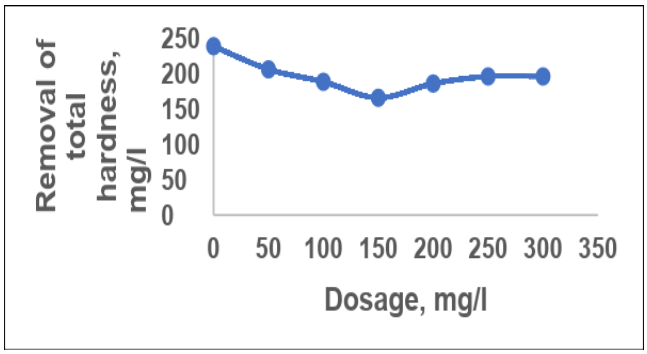


Figure 6: Total hardness as a function of marble powder

Hardness in water is due to the presence of calcium and magnesium ions. (Calcium chloride, calcium sulphate, magnesium chloride, magnesium sulphate etc) Since sulphates, chlorides, bicarbonates contain negative charge these ions get sorbed on the positive charged surface (calcium hydroxide). Because of this reason in figure 6 it can be noted that up to 150 mg/l and 100 mg/l dose of marble powder there is decrease in concentration of total hardness then there is a gradual increase and attains equilibrium. Reduction in concentration for about 30 % was achieved. Therefore 150 mg/l and 100 mg/l of dose is enough for the attainment of drinking water standards.

d) Variation in Total hardness

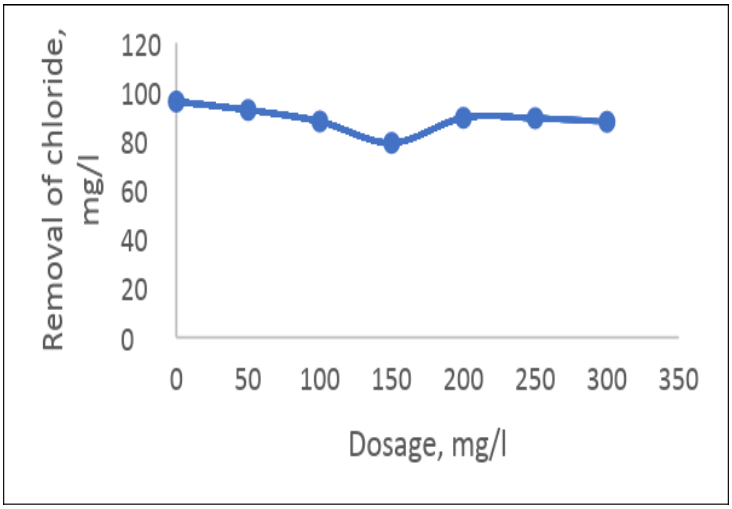


Figure 7: chloride removals as a function of marble powder

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Chloride content in water will be in the form of NaCl, KCl, MgCl2 As described earlier the formation of calcium hydroxides aggregates, the removal of chloride from water is due to force of attraction. From figure 7 as the dosage of arble powder increases the removal of chloride also increases. But this increase is seen up to 150 mg/l (Kukkarahalli Lake) and further there is slight increase or no removal takes place. This is due to the reason that negative ions get attracted to the positive surface. As the dose increase the surface area for removal also increases but after 150 mgL-1 and 100 mg L-1dosage the formation of various axles for binding of ions increases and hence removal of chloride does not occur. The concentration of chloride reduced 159mg/l to 79mg/l (38% reduction).

$$CaCO_3 + 2NaCl \quad CaCO_2 + 2Na + 2Cl^-$$

From the above reaction it can be noticed that chloride in the form of NaCl reacts with calcium carbonate to split into Na and Cl^- ions. These Cl- ions attached to the surface of calcium hydroxide and enhance in the removal of chloride.

e) Variation in phosphate concentration

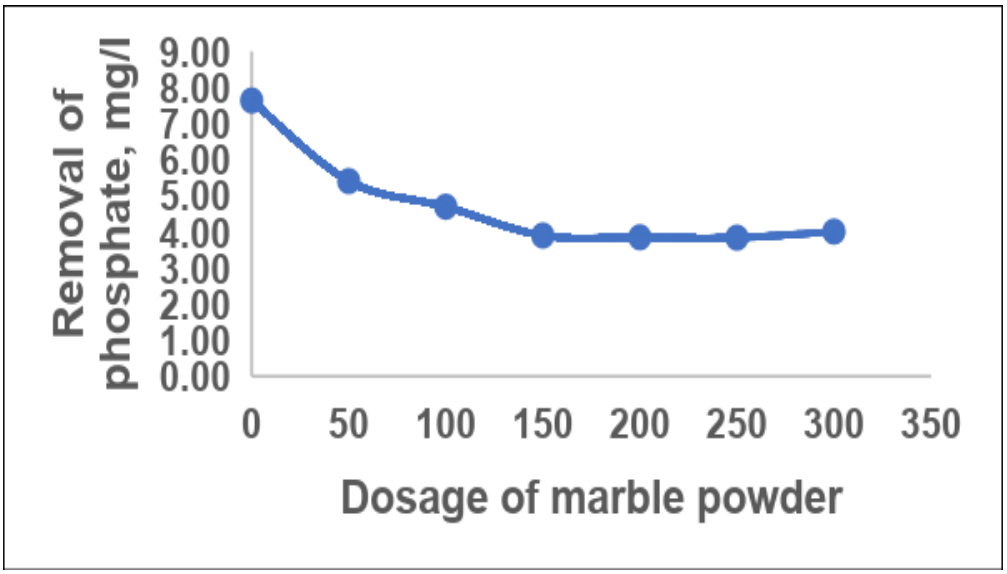


Figure 8: phosphate removals as function of marble powder

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Calcite sorbs phosphorus especially when pH exceeds 9.0 and results in significant phosphorus removal from the water column. Phosphate adsorbs at the calcite surface, or binds inside a crystal when calcium carbonate is applied. At high pH, and concentrations of Ca2+ and soluble P, hydroxyapatite is formed.

10 CaCO3 + 6 HPO42+ 2 H2O Ca10 (PO4)6(OH) 2 + 10 HCO3

Hydroxyapatite has its lowest solubility at pH >9.5 and bind phosphorus strongly at high pH. However, if the pH falls the solubility sharply increases and leads to P release. The reduction in concentration was observed 3.90 mg/l from 7.64 mg/l (about 50 %).

f) Variation in nitrate concentration

Nitrogen in water will in three forms i.e. nitrate-nitrogen, nitrite- nitrogen, and ammonical- nitrogen. When marble powder (CaCO3) 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 (Lingambudhi 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 removal was observed to be 3.20mg/l (60%).

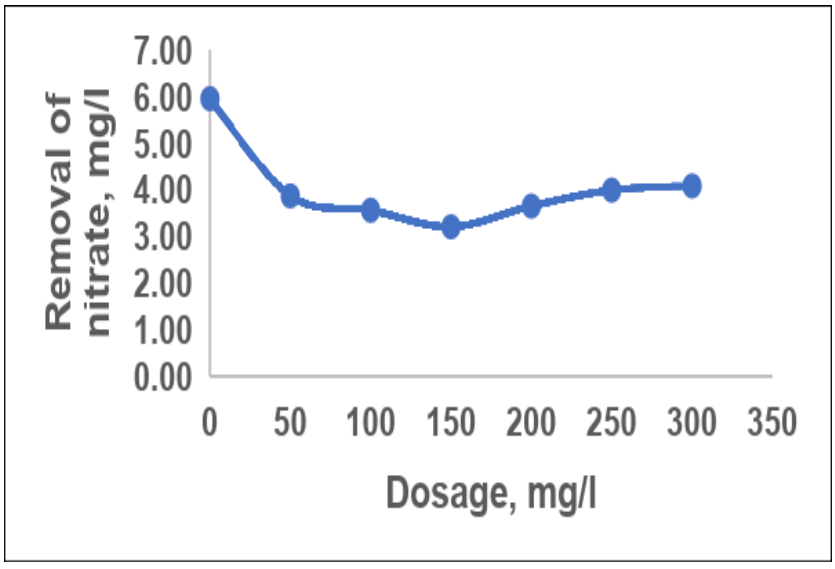


Figure 9: phosphate removal as function of marble powder

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Variation in contact time for obtained dosage

To determine the optimum contact time for the maximum removal the time interval was varied from 10-50 minutes. The optimum dosage of 150 mg/l was obtained for Kukkarahalli lake water sample. All the parameters analysed (total alkalinity, total hardness, chloride, nitrate and phosphate) had their maximum removal at a time period of 20mins (Kukkarahalli lake). At the beginning the concentration of removal was slightly increased later at 20mins and 30mins duration there was maximum removal of more than 50%. As explained earlier the ions having negative charged ions get adsorbed on the hydroxide ions and hence we can observe the removal but after a certain time duration the repulsive force produced does not allow for further sorption. Hence this experiment was conducted to know the optimum contact time for the maximal removal of physico- chemical parameters. The optimum contact time obtained was 20mins for the lake. Further at time duration for about 30-50mins equilibrium was achieved i.e. no further removal or constant removal. Figure 10 – 15 represents the interpretation of parameters with change in contact time.

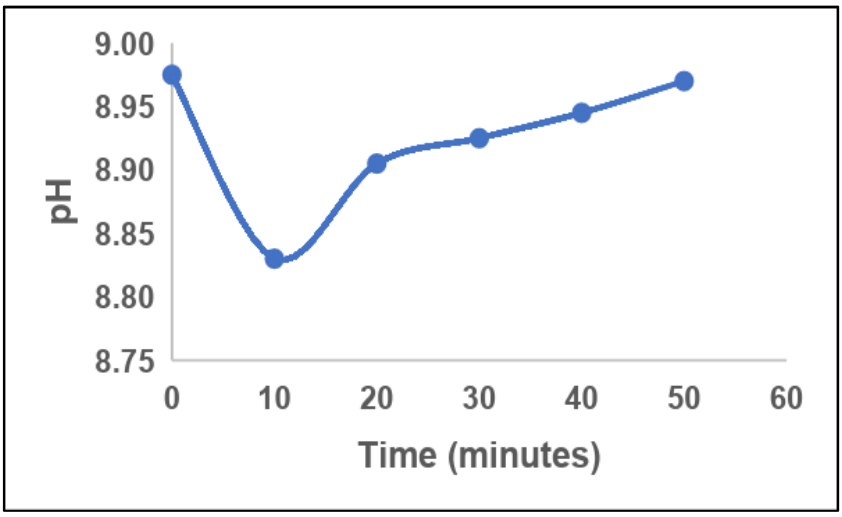


Figure 10: Effect on pH for varied contact time

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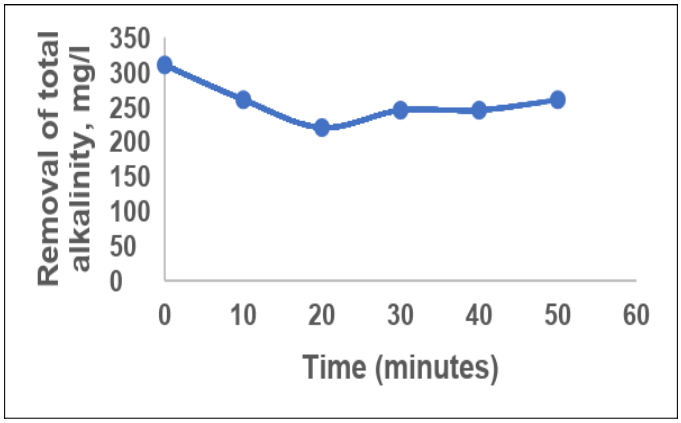


Figure 11: Effect on removal of total alkalinity for varied contact time

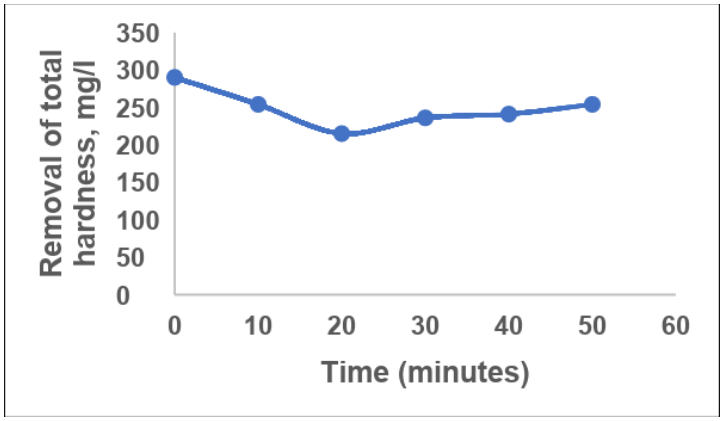


Figure 12: Effect on removal of total hardness for varied contact time

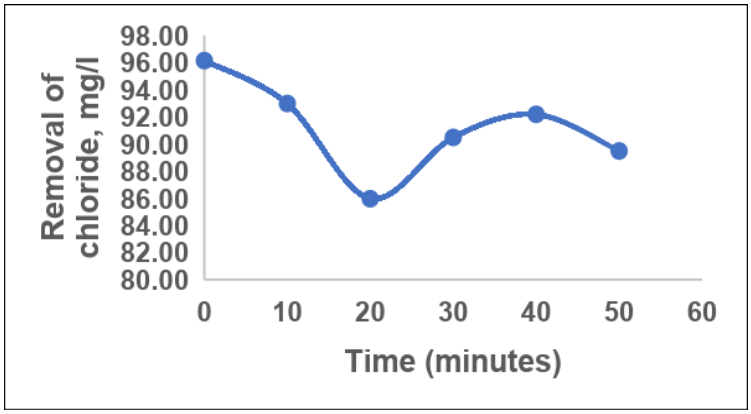


Figure13: Effect on chloride removal for varied contact time

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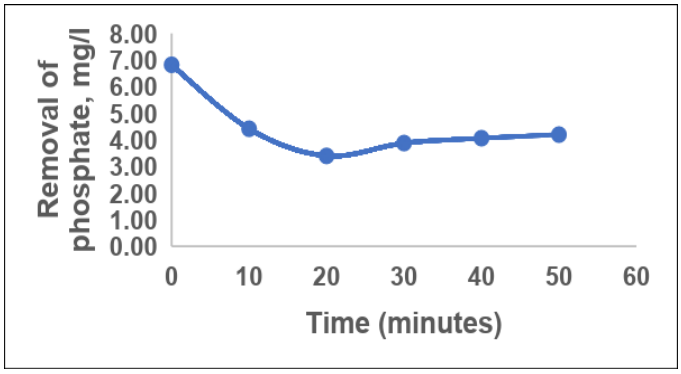


Figure14: Effect on phosphate removal for varied contact time

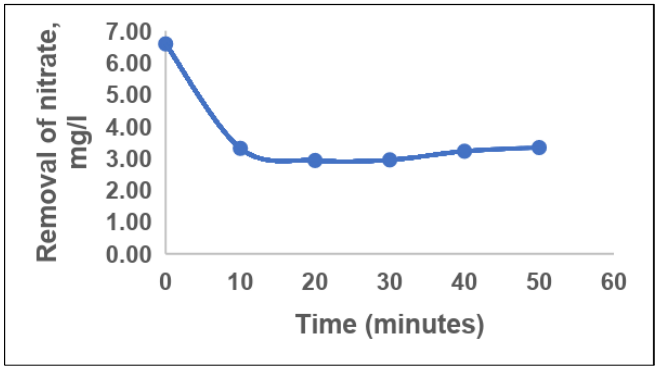


Figure15: Effect on nitrate removal for varied contact time

Calculation of requirement of total quantity of marble powder for obtained dosage

Table: 3

	Kukkarahalli lake
Lake catchment	414 hectare
Depth	4.6
Volume of water	Area x Depth
	414 x 4.6 = $1.9x10^6$ m^3 = $1900x10^6$L
Dose obtained	150 mg/l = 0.5 g/l
Total quantity of marble powder required	$1900x10^6x0.15$ = 28500 Kg
	= 285 tonnes

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CONCLUSION

The physico-chemical parameters analyzed showed that the amount of the total alkalinity, total hardness, phosphorous and nitrogen are exceeding the standard limit. On the addition of marble powder to water sample, no much variation was observed in pH slight increase was seen. Under mixing condition, using jar test analysis the optimum dosage of marble powder required to bring the concentration of parameters to standards was 150 mg/L for Kukkarahalli lake water sample.

The optimum contact time for maximum removal of parameters obtained was 30minutes.

Application of marble powder to lake directly requires careful examination and to get better results it must be evenly distributed throughout the lake

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