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RESEARCH ARTICLE

Detergent and Sewage Phosphates entering into Lake Ecosystem and Its Impact on Aquatic Environment

[1]V. Pattusamy, [2]N.Nandini and [1]K.Bheemappa

1. Research scholar, Department of Environmental Science, Bangalore University, Bangalore-560056. Karnataka, India

2. Associate Professor, Department of Environmental Science, Bangalore University, Bangalore-560056 Karnataka, India.

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Abstract

Detergent soaps and powders are used for washing clothes and are used in washing machines. Synthetic detergents are cleansing agents, which contains an active agent called surfactant that wets the fabrics, emulsifies oily matter, solubilises grime and keeps dirt in suspension. Phosphate originates mainly from detergents, human waste (Urine and faeces), agriculture run off and soil phosphates which reaches aquatic environment through sewage and affecting aquatic ecosystem. Different brands of commercially available synthetic detergent soaps, detergent powders and sewage were analysed for Phosphate content using Vanadate Molybdate method by standard procedure (APHA, 2005). The research finding states those Detergent builders Sodium tripolyphosphate ($Na_5P_3O_{10}$) can be substituted by a phosphate free Zeolite ($Na_2Al_2Si_3O_{10}.2H_2O$ - Aluminium silicate). There are no separate legislations available in India to Control phosphates in Soaps, Detergents and Sewage which is polluting aquatic environment. An attempt was made to draft legislation to reduce phosphate content in detergent soaps and detergent powders.

Introduction

Soaps and detergents are made of surfactants or surface-active agents, chemicals that help water soak and clean surfaces. Soap reacts with minerals in hard water, diminishing cleaning properties. Builders boost the efficiency of surfactants by counteracting hard water, emulsifying oil and grease, and preventing soil from redepositing. Phosphates are an environmentally delicate chemical and a commonly used detergent builder. Raw materials include surfactants, solvents, phosphates, silicates, alkalis, salts and perfumes. Phosphorus is in the form of phosphate in detergents and is used to soften hard water and suspend dirt in the water. Sewage containing human waste (Urine and faeces) phosphate and detergent phosphate are discharged into the water bodies leading to eutrophication of lakes.

A review by Feisthauer et al., (2004) on the problem of detergents is growing rapidly in developing Countries such as India where the use of detergents has grown manifold but the facilities for sewage treatment are extremely poor. Though the biological effects of detergents have been demonstrated extensively. The Environment Protection law (1989) in India recognises phosphorus as a chemical pollutant. Despite that, its usage is on the rise. In India, per capita consumption of detergents in 1994 was 2.8 kg per annum. This is projected to rise to over 4 kg/capita by 2005. In rural areas the use of detergent bars is expected to grow by 7-8 per cent annually. The figures are of concern because high-quality detergents have as much as 35 per cent Sodium tripolyphosphate (STPP) in them. Most laundry detergents in India are phosphate-based, but there is no control or regulation for phosphate use in detergents. The main problem is that of phosphate-based detergents promoting eutrophication of aquatic environments.

***Corresponding author:** vpattusamy@gmail.com*

The fact that the phosphates in these detergents can cause eutrophication of waterways portends a grim situation, since these water bodies are the primary sources of water for a large section of the population.
So far, India's action towards controlling advanced eutrophication has been addressed and dealt with only through sewage treatment plants (STPs). Despite several action plans, the issue remains largely ignored. The ever- increasing demand of phosphate-laden detergents in rural areas is sure to escalate eutrophication of local water bodies that serve as the primary water resource. Washer man (Dhobis), rural and urban women extensively use phosphate containing detergents. There are various rules and regulations like the law of Environmental Protection in India (1989), and the Hazardous Waste Rules (1989), which categories phosphine and phosphorus and its compounds as toxic chemicals. Such regulations, however, are not applied to household detergents. The Bureau of Indian Standards (BIS) has also laid down the standards for eco-labelling i.e. Ecomark of detergents in India during 1991 Stressing on the aspects of the surfactants used in the manufacture of household laundry detergent powders that should be readily biodegradable and the products be packed in packages made of recyclable or biodegradable materials.
The Swedish Chemicals Agency has made several impact assessments on restrictions of phosphates in detergents for consumer use. The inputs of phosphorus resulting from the use of phosphates in detergents are rather variable depending on the country. The estimations made before the introduction of phosphate-free detergents have shown that about one third of the phosphorus in human sewage may be attributed to phosphorus in detergents i.e. 1g/person per day (Swedish Society for Nature Conservation - SSNC, 1998). The inputs from agriculture were higher. However Gren*et al*., (2008) opined that more expensive to reduce inputs from agriculture than to introduce phosphate-free detergents. Other sources mention that phosphorus from detergents might contribute with 25 per cent of the phosphorus loading on an average. Phosphorus in detergents is especially important where inputs are dominated by point sources and removal of phosphorus is still missing (Kohler, 2006). Phosphate removed from sewage may be reused in agriculture.
Separate legislation is required to limit the phosphate content or substituted by Zeolite in detergents. Country like Canada banned the sale of phosphate-laden dish detergents in 2010. Numerous United States cities and municipalities banned the phosphate both in detergents and fertilizers in an effort to minimize runoff.

Material and Methods

Changes in lake food webs and biogeochemical cycling of phosphorus led to bloom nuisance algae in Bangalore lakes. Therefore a technology is designed to remove Phosphate pollution from the lakes. Phosphate pollution test was carried out using commercially available, different brands of Detergent soaps and powders. The detergent soaps were given a code of A to H, Dish wash bars as J and K,Soap Powders as L to O. Phosphate content in Detergents and sewage were analysed using Vanadate Molybdate method by following standard procedures (APHA, 2005). Detergent Soap and Powder were converted to ash by using Muffle furnace in at 250^0C for 2 hours to avoid soap interference colour in the analysis, the ash was dissolved in 100ml of distilled water, 1ml of Conc. HCl acid was added and boiled for 20 minutes to hydrolyse the phosphate. The filtered solution was made up to 100ml. Out of this 2ml or aliquot of sample was taken for the phosphate analysis and measured absorbance at 400nm using Visible Spectrophotometer (UV2300II). Same procedure was followed for the analysis of phosphate in Sewage collected from Ulsoor and Madiwala area which is directed to lakes in those areas. Phosphate was calculated using the formula:

mg P/L= mg P (in 50ml final volume) X 1000 / ml sample

The Phosphate content in sewage (near Madiwala) and sewage sample (Downstream of Agaram Lake series near Mugalur) were treated with coagulants like Aluminum Sulphate 50mg (5% Al_2SO_4, 1ml), 50mg of Ferrous Sulphate ($FeSO_4$, 1ml), 50mg of Ferric Chloride ($FeCl_3$, 1ml) and 50mg of Aluminum potassium Sulphate (5% $AlKSO_4$, 1ml). The Precipitate dried at 300^oC and the filtrate was analysed for Phosphate concentration.

Results and Discussion

Phosphate pollution in surface waters by point and non-point sources is a major national environmental issue. Phosphate is capable of tying up calcium, Magnesium, Iron and Manganese ions thereby improving overall phosphate detergent washing performances (Duthie, 1972).

Table 1: Analysis results of Phosphates in Detergent Soaps and Powder

Sl No.	Name of the Soap(Code)	Phosphate Concentration mg per 100g of Soap/Powder
1	Soap - A	60
2	Soap – B	Very high Colour interference
3	Soap – C	Nil
4	Soap – D	175
5	Soap – E	Nil
6	Soap – F	15
7	Soap – G	125
8	Soap – H	Nil
9	Soap Dish wash Bar - I	Nil
10	Soap Dish wash – J	Nil
11	Soap powder – K	500
12	Soap powder – L	104
13	Soap powder – M	Nil
14	Soap powder – N	Nil
15	Soap powder - O	Nil

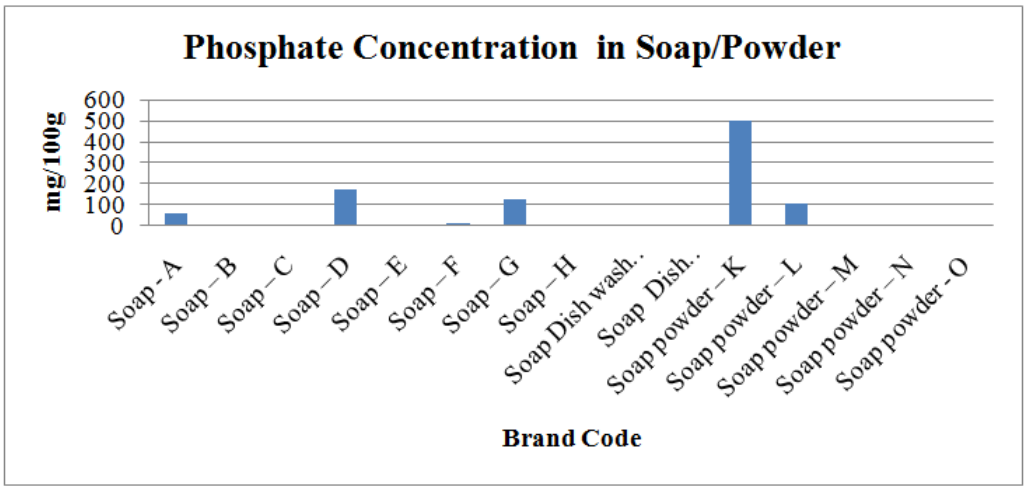
Table 2: Analysis results of Phosphates in Sewage

Standards and Sample concentrations	**Reagents**	**Distilled water**	**Instrument and Range**	**Results**
Blank	10ml Vanadate Molybdate solution	35 ml distilled water make upto 50ml	UV-Visible Spectro photometer UV2300 II at 400nm	Standards
50µg Phosphate solution				
100µg Phosphate solution				
200µg Phosphate solution				
400µg Phosphate solution				
800µg Phosphate solution				
5ml sewage sample (Downstream of Agaram Lake seriesnear Mugalur)				2mg/L
5ml Sewage sample (near Madiwala)				8mg/L

Table 3: Analysis results of Phosphate content in sewage (Madiwala) and Sewage sample (Downstream of Agaram Lake series, Mugalur) water after treating with Coagulants

Sample concentration	**Coagulants**	**Precipitate**	**Filtrate**	**Results**
250ml Untreated sewage (Madiwala) and sewage sample (Downstream of Agaram Lake series, Mugalur)	50mg of Aluminum Sulphate (5% Al_2SO_4,1ml)	dried at 300^oC and ash may be used for agricultural purpose	Analyzed for Phosphate	Phosphate was found Nil
	50mg of Ferrous Sulphate ($FeSO_4$, 1ml)			
	50mg of Ferric Chloride ($FeCl_3$, 1ml)			
	50mg of Aluminum potassium Sulphate (5% $AlKSO_4$, 1ml)			

Figure 1: Concentration of Phosphates in Detergent Soap and Powder



Phosphate detergents are generally safe to use with minimal toxicity. The higher levels of phosphates in lakes are due to run off results in eutrophication. Algal bloom in lakes threatens the aquatic environment. Analysed results of phosphate in commercially available synthetic detergent soaps and detergent powders (Table 1) shows that, The Phosphate concentration in soap ranged between 0 to 500mg/100gm. Soap brand from A to H results showed that maximum concentration of 175 mg/100g were recorded in Soap 'D', minimum of 15 mg/100g was recorded in Soap 'F', Soap Dish wash Bar- J and K was recorded as nil for Phosphates. In Soap powders the maximum phosphate concentration of 500mg/100g was recorded in 'K' and minimum of 104mg/100g in Soap powder 'L'. There was a negligible concentration of Phosphate recorded in Soap 'E', 'M', 'N' and 'O'. Out of the 15 soaps and detergents tested 7 soaps and detergents recorded nil, 8 were recorded between 15- 500mg/ 100g of phosphate concentration.

The untreated sewage phosphate was treated by adding different types of flocculants as indicated in table 2. The analysis results of Phosphate with different concentrations revealed that Phosphate concentration in untreated sewage (Madiwala) and sewage sample (Downstream of Agaram Lake series, Mugalur) water was recorded as 2mg/L and in raw Sewage as 8mg/L. The Coagulants like Aluminum Sulphate, Ferrous Sulphate, Ferric Chloride, Aluminum potassium sulphate were added to the samples of untreated sewage and sewage sample (Downstream of Agaram Lake series, Mugalur) and the results of Phosphate concentration was recorded as nil. The recovered phosphate was used in agricultural activities as nutrients.

International Joint Commission (1980) report on water quality states that major component of the total phosphorus inputs to the lakes is domestic wastewater and household detergents. The study of Hammond (1971) also supports this study that detergents accounted for about 50% of the waste water phosphorous in United States.

Catie Burnside and William McDowell (2001) in their study revealed that although most liquid detergents for hand-washing dishes are phosphorus free, detergents for automatic dishwashers typically have high phosphorus content, as tripolyphosphate is preferred as water-softening agent.

Excess nutrient (Phosphate and nitrogen) in surface water enhances the algal bloom. Detergents can have poisonous effects on all types of aquatic life if they are present in excess quantities. This includes the biodegradable detergents. Surfactant detergents are also implicated in decreasing the breeding ability of aquatic organisms. Detergents also add another problem for aquatic life by lowering the surface tension of the water. Abel (1974) reported that Synthetic detergents are acutely toxic to fish. Factors that are affecting toxicity include the molecular structure of the detergents. The interactions between detergents with proteins and their influence on membrane permeability may be the basis of the biological action of detergents. Detergents in natural waters are usually partially degraded, and a maximum permissible concentration of 0.5 mg/L would probably be harmless under most conditions. Results from this investigation showed that the concentration were more than the permissible limits. Phosphate-containing detergents can create algal blooms in fresh water. Nutrient loading with phosphates from laundry and dishwasher detergents, as well as from suburban lawn chemicals, can lead to

eutrophication, a process by which a freshwater aquatic ecosystem slowly dies due to continual oxygen depletion.

Conclusion:

Detergent Phosphate (Sodium tri poly phosphates $Na_5P_3O_{10}$) and human waste phosphate reaches surface water like Rivers, Ponds and Lakes. Surface water becomes eutrophic. Detergent phosphate can be substituted by Zeolite.

Municipalities should treat sewage for phosphate and nitrogen removal. Detergents contain chemicals that can harm the human body as well as the natural environment. Clive Southey et al., (2001) deliberated that in despite laying down of an Ecomark plan by BIS (1991), which encourages phosphate free and environment friendly detergents to the consumer. There is a need of multiple controls on use of phosphorus to achieve the desirable water quality conditions. The Indian government has not taken enough steps to address these problems. Without mandatory legislation, industry does nothing to reduce the levels of harmful chemicals, or to inform the consumer about potential damage. This is even true of multinational firms who are forced to follow much stricter norms in Western countries Like Canada and United States. The Proposed legislation should be passed in the parliament and should be initiated by Ministry of Environment and Forest. The recommended standard for Phosphate limit in detergent should be 0.5% of the total weight. In all municipalities sewage treatment, removal of Nitrogen and Phosphate should be made compulsory by separate legislation. Awareness needed at consumer level regarding the phosphate contents in detergents, its impact on the environment and also to encourage that the smaller detergent products which are least polluting the water bodies.

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