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A Critical Analytical Study on Certain Popular Indian Detergent Powders with Respect to the Related BIS Specifications and Their Environmental Impact

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Abstract:

A 'consumer-point' critical analytical study was conducted on the quality of some of the popular detergent powders sold in India with respect to their active matter, water-insoluble mineral matter, total alkalinity, and presence or absence of phosphates. The problem of adverse environmental impact of the detergents owing to the pollution-creating active matter that generates foam ; phosphates, found in 3 out of 11 samples ; and slush-creating insoluble mineral matter, present in 10 out of 11 samples, were also critically discussed. The study was also focused on the utter futility of the official specification, I.S. : 4955 – 2001, issued by the Bureau of Indian Standards (BIS), meant for assessing the efficacy of the marketed laundry detergent powders. None of the branded detergent powder packets showed ISI mark issued by BIS. Also, none of the packets showed any of the characteristics enlisted in I.S.: 4955 – 2001, viz., active ingredients, total phosphates, sodium tripolyphosphate (STPP), active alkalinity, % detergency, and % ash built-up. It is concluded that chemical composition and quality of detergent powders manufactured in India is controlled by the manufacturers' own whims and fancies, and not by BIS specification. On the contrary, BIS specification itself is plagued by impractical test characteristics which are also grossly ignored by manufacturers, and consumers are also totally unaware of all these.

Keywords: Active matter, alkalinity, detergency, detergent powder, mineral matter, phosphates, STPP.

1.0 Introduction:

A 'consumer-point' critical analytical study was conducted on some of the popular detergent powders sold in India with respect to their active ingredient content / active matter, total alkalinity, pH, water-insoluble inorganic matter, and presence or absence of phosphates. The detergents / surfactants come under one of the top most fast moving consumer goods (FMCG) category in the daily life of the universal society. Whereas the Indian detergent industry is worth multithousand crores of rupees, but it is ruled only by a small number of multinational players. As a result of continuous urbanization in the country, the demand of the detergents, especially the detergent powders, is constantly rising.

Synthetic detergents are a group of compounds having specific chemical composition of their molecules (whose one part is hydrophilic which is soluble in polar medium like water; and the second part is hydrophobic in nature that is either sparsely soluble or insoluble in polar medium). By varying the hydrophilic and hydrophobic moieties of the surfactants, several of its properties can be adjusted so that to make them more useful. The adjusted properties include the wetting ability, emulsifying ability, dispersive ability, foaming ability, etc. The main classification of surfactants is based on charge on the hydrophilic part of their molecules--cationic, anionic, and nonionic compounds (Bajpai and Tyagi, 2007; Olkowska *et al*., 2011). The linear alkyl benzene sulfonic acid (LABSA), also known as acid slurry, is the chief raw material of most of the detergent powder brands manufactured in India. A comprehensive review paper presented by Konnecker *et al*. (2011) summarizes the environmental hazard assessment of physicochemical properties, environmental fate and behavior as well as toxicity of a category of 61 different anionic surfactants.

The adverse environmental impact owing to the pollution-creating active matter (that generates foam), phosphate additives, and slush-creating insoluble settleable inorganic minerals--which are added mostly as weight-increasing fillers--is also discussed in the present paper. Our study is also focused on the utter futility of the two official specifications, issued within a span of nineteen years, by the Bureau of Indian Standards, BIS (as I. S. : 4955 – 1982 & I. S. : 4955 –2001), meant for assessing the efficacy of laundry detergent powders. The one standard fact that has emerged following the completion of our study on the tested / studied samples is : 'None of the Indian detergent powders showed on its marketed packet, quality assurance mark (ISI) from the Bureau of Indian Standards, despite its Specification No. 4955 having been in existence since 1982 (revised in 2001). Also, none of the detergent-manufacturers was found to be paying any heed to at least some (if not all) of the requirements of the BIS specification(s). This observation demonstrates that the production of detergent powders in India is being done without any quality control (i.e., by fully violating BIS specifications) and also by disregarding other regulations relating to the norms of environmental pollution, etc'.

Although synthetic detergents are unavoidable commodity of daily household need, but after the use by the consumers, when waste water from homes is released into the drains, these detergents can cause far-reaching environmental impacts. These impacts happen to be in correlation with the chemical composition **/** ingredients of the detergent powders. Thus, drained-out detergent-wastes can have poisonous effects on all types of aquatic life if they get accumulated there in sufficient quantities. The findings put forward by Ogbulie *et al.* (2008), Ghose (2009), and Hidayat (2011), demonstrate that high concentration of detergent in water can cause the destruction of external mucus layer of fish and severe damage to their gills. Anionic detergents cause environmental problem such as foam production which hinders the spinning of turbines and aerating devices in waste water purification plants. According to Chaturvedi and Kumar (2010) sodium dodecyl sulphate (SDS) also enhances absorption of chemicals through skin, and mucous membrane. Ivankovic and Hrenovik (2010), and Olkowska et al. (2014), have provided good information about the impact of surfactants on the environment.

In India, all the manufacturers are seemed to be setting the chemical composition of their products on the basis of their own whims and fancies or profits. Hence, their impact on aquatic life, where they eventually end up, may be as bad as those coming from industrial wastes including tannery effluents. The frequent occurrence of thousands of dead fish being found floating in the Ganga river in Kanpur cannot always be linked to the industrial wastes; the domestic effluents containing detergent waste-waters may also be hugely responsible for such ghastly scenes. Such kinds of uncanny scenes of Ganga water pollution have quite often been reported in the local newspapers of Kanpur city.

Our present research work was aimed at taking up a critical analytical study on the quality of certain easily available popular Indian detergent powders with respect to the recommendations in the related BIS specifications, and also the nature of their chemical composition, as well as their after-use hazardous environmental impact on the water bodies. Additionally, the authors wish to create consumer awareness in the country so that the people could become aware about the quality of the detergent powders that they are buying from the market. At the same time the authors wish to alarm the manufacturers of detergent powders for raising the standard of their product. The authors also call upon the Government of India to take steps for encouraging the establishment of phosphate-free detergent powder industries in the country, as is the current practice in many other right thinking countries (Nielsen and Schaetz, 2012). Our research work is also aimed at awakening the BIS plenipotentiaries to create and issue a sensible quality of specification for the quality control of the detergent powders sold in the Indian markets. Since the current BIS specification (I. S.: 4955 – 2001) has failed to attract the attention of the manufacturers as well as the consumers, it should be considered as redundant. Any new specification that is to be issued in future should not be mere a copy of the characteristics enlisted in the similar specifications of the western countries.

2.0 Materials and Methods:

A total number of eleven brands of marketed detergent powders were procured from the open market, and taken up for the study.

Table 1: Detergents and details of product

S.N.	Brand Name	Sub-title	Manufactured by	Batch No.
1.	Tide	Natural fragrance of lemon and chandan	Procter & Gamble, Mumbai	3092 (01/2014).
2.	Surf Excel	Easy Wash	Hindustan Unilever Ltd. (HUL) Mumbai	C50/2554 (28-9-2013)
3.	Rin	-	Hindustan Unilever Ltd. (HUL) Mumbai	27-01-14/C
4.	New Super Check	with extra power : Orange fresh	Jyothi Consumer Products Marketing Ltd., Mumbai	B115 (01/2014)
5.	Active Wheel Lemon	Lemon & orange	Hindustan Unilever Ltd. (HUL) Mumbai	21-01-14/C1
6.	Nirma Advance	-	Nirma Ltd., Ahmadabad	Packed 05/2013
7.	Patanjali (Herbal)	Detergent powder with herbs	Patanjli Ayurveda Ltd., Haridwar	0185/07-13
8.	Superior Plus	Flowering Lemon Fresh	Corona Plus Industries, Mumbai	06/13
9.	Ghadi	-	RSPL Ltd., Kanpur	01/2014
10.	Surf Excel Quick Wash	Quick Wash	Hindustan Unilever Ltd. (HUL) Mumbai	22-07-13/S2
11.	Teen Ikke	-	Ankit Gramodyog Sansthan, Nunhan Kalan, Chaubepur, Kanpur	06/12

2.1 ***Determination of active ingredient content (active matter)*****:** The active ingredient content or active matter (as sodium alkylbenzenesulphonate, M. W. = 348) was determined as per I.S. : 4955-1982 and I.S. : 4955-2001, by the cationic titration method**.**

2.2 ***Detection of phosphate :*** The presence or absence of phosphate in the detergent powder samples was carried out only qualitatively after incinerating the powder to ash form, and then testing the phosphate by the usual methods (Furman 1962).

2.3 ***Alkalinity of the detergent powder samples:*** The total alkalinity of the detergent powder samples was determined as per cent soda ash (as Na_2CO_3) content by the simple acid-base titration method **(Greenberg *et al.* 1992).** The alkalinity was found to be in the range of 22.00% to 39.60 %. Except in the case of Tide (22%), in all other samples the soda ash content was found to be more or less sufficient for a good cleaning of clothes.

2.4 ***Water-Insoluble mineral content (as filler):*** The water-Insoluble mineral content in the samples was determined gravimetrically**.** And it was found to be present in the range of as low as 11.56 % to as high as 33.35 %. Mostly, such inorganic natural materials were identified as calcite, kaolin, and pyrophyllite, which were added as fillers to create weight and volume to the detergent powder packets.

3.0 Results and Discussion:

3.1 ***Active ingredient content*****:** As per BIS specifications (I. S.: 4955 – 1982 & I. S.: 4955 –2001), the active ingredient content in a detergent powder should not be less than 10 per cent for Grade 3; minimum 15/16 % for Grade-2, and minimum 19 % for Grade 1. During the present study (Table 2 and Fig.3) only one sample, Surf Excel Quick Wash, had passed for Grade-1 quality with as much as 21.13% active matter. Two samples, New Super Chek (9.37%) and Superior Plus (9.90 %) failed to qualify even for grade -3 quality powder for showing active ingredient content below the minimum requirement of 10.0 %. Out of remaining 8 samples, only Surf Excel, with 18.00 % active ingredient content, qualified for the Grade-2 material. Rest all 7 samples passed for Grade-3 quality powder. Higher the percentage of active ingredient of the detergent powder samples, greater is its fabric washing quality. Moreover, a sample having a very high active ingredient percentage, then its small quantity will be sufficient to perform the same function as in the case of a lower grade sample that would require double of its quantity.

***3.2 The environmental impacts of active ingredient content*:**

Although, from the consumers' point of view, a good cleaning quality detergent powder should have a higher foam-creating active ingredient content, but unfortunately all detergents (due to their active ingredient or active matter content) tend to destroy the external mucus layers that protect the fish from bacteria and parasites. Not only this, these can also cause severe damage to the gills of the fish. Zimring and Rathje (2012) have found that most fish will die when detergent concentrations approach 15 ppm in the water body. Detergent concentrations as low as 5 ppm is reported to be capable of killing the fish eggs. Ying (2006) has demonstrated that chronic toxicity of surfactants occurs to aquatic organisms when they are present at a concentration of 0.01 mg/L. Detergents have also been found to be decreasing the breeding ability of the aquatic-organisms (Hill 2010). This fact is further substantiated by the fact that at several edges of the banks of the Ganga river, in Kanpur and Unnao cities, hugely dirty foaming matter is quite often seen with dead fish entangled within. The entrance of laundry detergent waste into the water bodies like rivers, canals, lakes etc., causes immense damage to the aquatic life. Not only this, same contaminated water from these reservoirs used for irrigating the farms growing vegetables etc., makes them toxic. The toxicity increases with the increasing content of the detergent moiety (Ghoochani et al., 2011, and Azizullah et al., 2012). Further, since surfactants, or surface-active agents possess the tendency to reduce the surface tension of oil and water, the reduced surface tension of water also makes it easier for aquatic life to absorb pesticides, phenols and other pollutants from the polluted water. The Environmental Protection Agencies (EPAs) of various countries also warn that surfactants can disrupt the endocrine systems of humans and animals.

3.3 *The environmental impacts of phosphates in detergent powders*:

As shown in Table 2, only three out of eleven samples tested, showed the presence of phosphate. These are 'Nirma Advance', 'Superior Plus', and 'Surf Excel (Quick Wash)'. The caustic-natured toxic phosphates are used in detergents for softening the hard water and for allowing the suspended dirt in water to settle down easily. The Lenntech.com in its article titled "Detergents occurring in freshwater" has very appropriately described the consequences of detergents getting into the freshwater ecosystems. Phosphate-containing detergents are also known to be capable of creating high algal growth in fresh water as shown by Fried *et al*. (2003). This problem occurs because phosphorous from detergents (and nitrogen from the decaying organic matter) combining together act as good nutrients that stimulate excessive growth of algae and other aquatic vegetation. Nutrient loading with phosphates from laundry detergents can lead to eutrophication a process by which a freshwater aquatic ecosystem slowly dies down due to continual oxygen depletion. That's why phosphate-containing laundry detergents are banned in most of the American states since the year 2010. Whereas Italy had started phasing out of the phosphates in detergents right from 1980s, Australia has imposed a total ban on phosphates with effect from this current year---2014. In many other countries, penalties and extra levies are imposed to the companies manufacturing phosphate-containing detergent powders. Sodium tripolyphosphate (STPP) is mostly used as phosphate ingredient in many detergents. But the use of STPP has been associated with the serious environmental problem of "eutrophication" which can lead to the formation of uncontrolled large masses of algae or blooms which create a bad scene (Fig.1 & Table – 2). Internationally, serious attempts have been made to limit the use of phosphates in detergent powders (J. Kohler, 2006 and East African Standard for synthetic laundry detergents for household, 2011). Lee (1973) has stressed the necessity for initiating in-lake control of eutrophication-causing phosphorus by the addition of alum or iron salts.

The phosphate also cause slow moving or stagnant waters to become turbid, and mostly toxic too due to the massive generation of a wide variety of deadly bacteria and viruses. The extent of eutrophication can only be effectively reduced by banning the use of phosphate ingredients in detergent powders. The Bureau of Indian Standards freely recommends the addition of STPP up to 9.5 % and total phosphates (expressed as STPP calculated from P_2O_5 content), up to 19.0 %. This is highly undesirable. Being environmentally harmful, the practice of adding phosphates in detergent powders deserves to be prohibited. Thus, first of all Sl. No. iii and iv of the characteristics in the BIS specification (I.S.: 4955-2001) regarding phosphates / STPP must be deleted.

Instead there should be a clause with warning that the product (detergent powder) must be phosphate-free, and the packets must also depict a sign like, " XP " (meaning, phosphate-free or no phosphate).

Fig. 1: The excessive phosphate-generated growth of algae / bloom in Lower Ganga Canal near J. K. Temple of Kanpur city.

A group of Indian researchers, (Pattusamy *et al., 2013*) have recommended that detergent builder STPP ($Na_5P_3O_{10}$) can be substituted by a phosphate-free Zeolite ($Na_2Al_2Si_3O_{10}.2H_2O$ - Aluminium silicate)**.** This group of Indian researchers has also made an attempt to draft legislation to reduce phosphate content in detergent soaps and detergent powders, because so far there has been no separate legislations available in India for controlling the addition of phosphates in soaps and detergents which have been badly polluting the aquatic environment of India.

3.4. *Alkalinity of the detergent powder samples*:
In correlation to the alkalinity, the pH values of all the tested samples in the present study were also found to be between the range of 10.0 to 11.0, as recommended (*not below 9.0 and not above 11.0*), in many of the international specifications. However, whereas I.S. 4955-1982 followed this norm (for pH of 1.0 % solution), in a sensible manner, but in I.S. 4955-2001 this norm has been substituted with an entirely haphazard, non-comprehensive as well as non-cognitive style, that reads as follows :
"Active alkalinity (ml of 0.1 N HCl to titrate 50 ml of 1.0 % product solution to phenolphthalein end point" "Requirement: 15, 20, and 30)." The authors of this paper urge the BIS plenipotentiaries to review this particular characteristic, and ask them to replace it with the one used in the current research paper (i.e., Total alkalinity as % Na_2CO_3 determined by the direct and simple acid/base titration method), and then assigning or recommending some minimum % Na_2CO_3 content in the specification. This type of pattern would only be understandable to the manufacturers as well as to the common consumer.

3.4. *Water-Insoluble mineral content (as filler)*:
Mostly, such inorganic natural materials were identified as calcite, kaolin, and pyrophyllite which were added as fillers to create weight and volume to the detergent powder packets. Out of millions of tons of detergent powders of various brands manufactured in India, tens of thousands of tons of water-insoluble mineral matter is released in to the drains as well as rivers where they create wanton mud and slush. Before the year 2001 when I.S. 4955-1982 was in force, only 1 to 2 per cent of the water-insoluble matter was permissible in the detergent powders. But in the revised specification (I. S. 4955-2001) the entire characteristic relating to the insoluble matter was mysteriously deleted. This started giving a free hand to the manufacturers for adding any quantity of water-insoluble matter they wish for profit-making. That's why in the present study, we have found the presence of insoluble matter ranging from 11.56 % to as high as 33.35 %. Only in one exceptional case, Tide, the insoluble matter was found to be only 3.10 % the lowest, and hence, best of all the tested samples. The authors of this paper are of the view that if mud / slush pollution in water bodies arising out of detergents is to be reduced, the earlier characteristic No. **v** of I. S. 4955-1982 must be reintroduced in the BIS specification. Even in the East African Standard for synthetic laundry detergents not more than 5.0 % of water-insoluble matter has been made permissible.

In the case of PATANJALI (Detergent powder with herbs), with special reference to Neem, it was not possible to identify the presence of the Neem content as claimed by the manufacturer. A qualitative test for detecting Neem in detergents is neither available in the literature nor it is mentioned on the detergent powder packet itself. The 'Neem detergent' terminology presented by the manufacturer seems to be a cosmetic ploy only in order to attract customers by any means. How the sedimentation of insoluble mineral matter in river beds causes shortening of river depths is depicted through the flow sheet diagram (Fig.2)

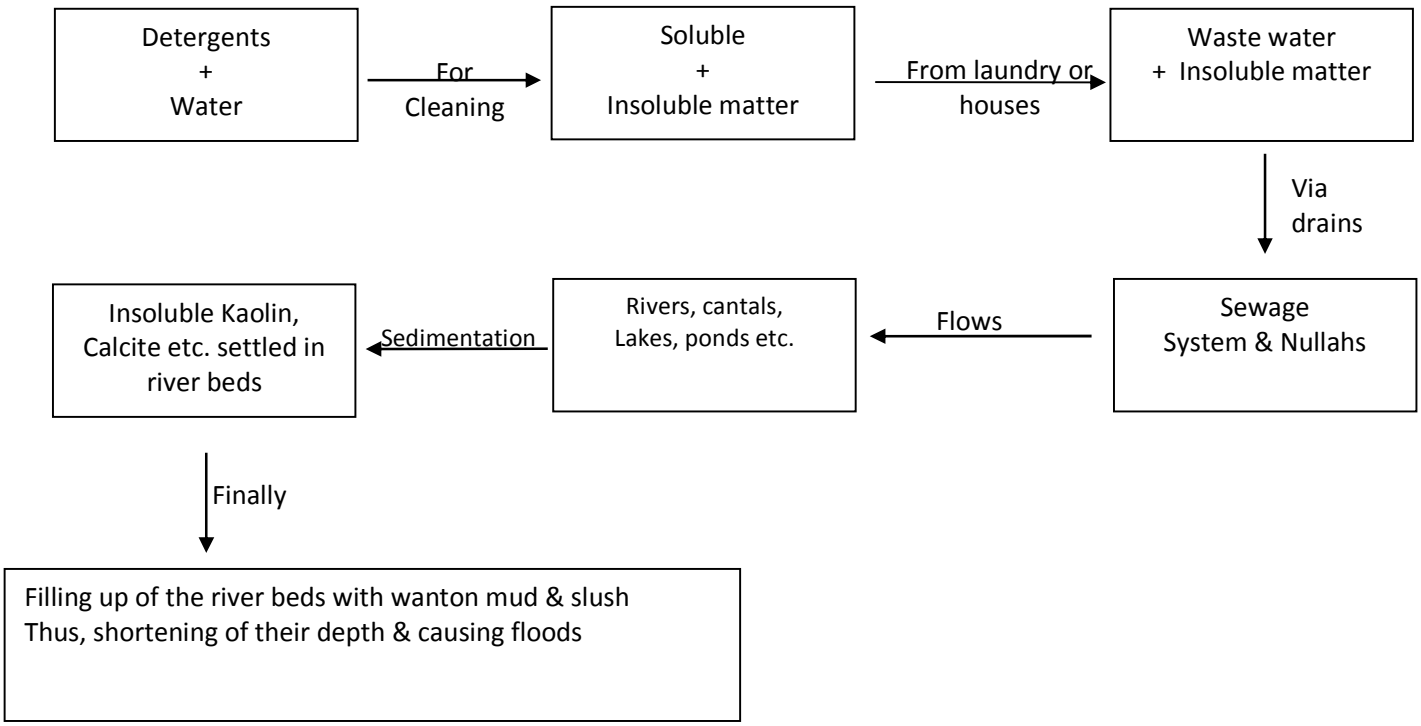

Table 2: Product and its contents

S.N.	Brand Name	% Active Ingredient	Total Alkalinity(as % Na_2CO_3)	Insoluble Matter (Calcite, Kaolin, Pyrophyllite, etc.)	Presence of Phosphate
1.	Tide	10.10	22.00	3.10	Nil
2.	Surf Excel	18.00	22.00	11.56	Nil
3.	Rin	15.87	26.28	17.12	Nil
4.	New Super Check	9.37	32.25	26.56	Nil
5.	Active Wheel Lemon	12.90	27.00	32.20	Nil
6.	Nirma Advance	14.01	39.60	16.08	Present
7.	Patanjali (Herbal)	12.00	37.20	16.25	Nil
8.	Superior Plus	9.90	27.60	27.95	Present
9.	Ghadi	11.45	35.12	17.62	Nil
10.	Surf Excel Quick Wash	21.13	38.30	20.27	Present
11.	Teen Ikke	11.10	32.21	33.35	Nil

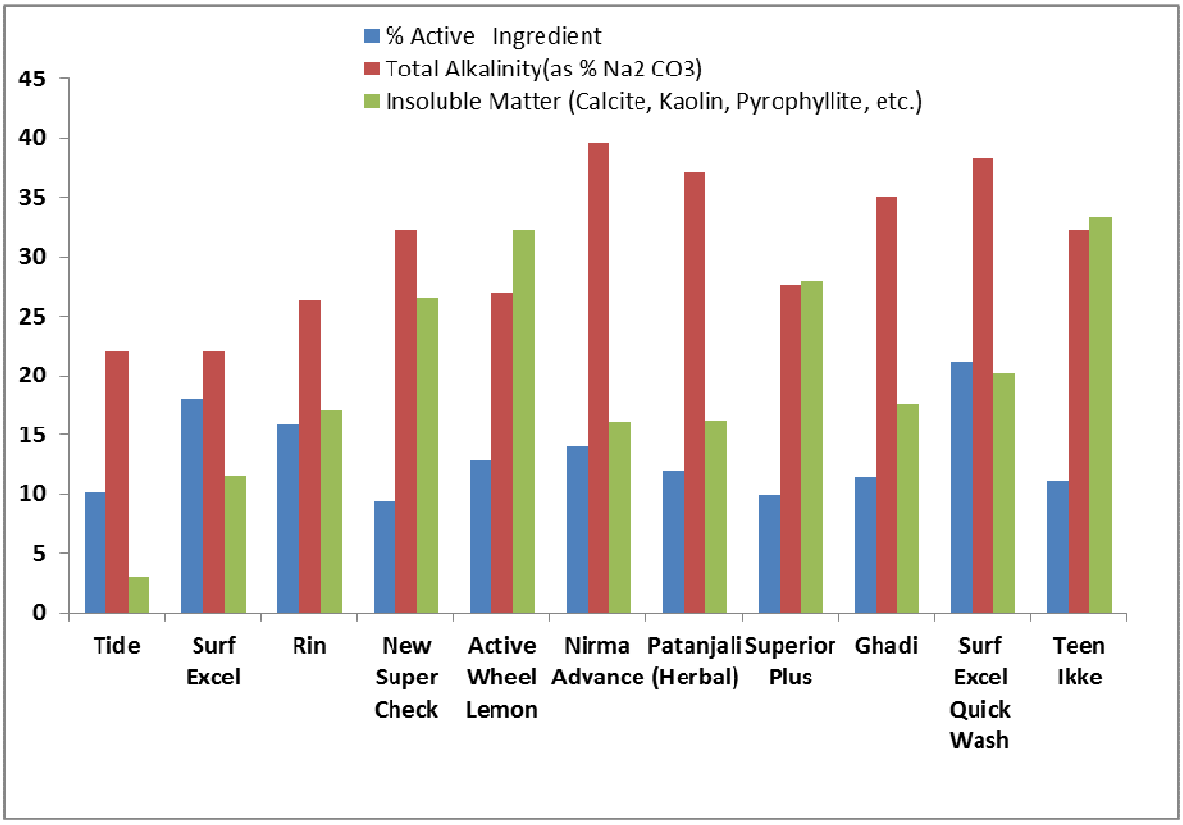

Fig. 3: Comparison of % variation of active matter, alkalinity and insoluble matter of detergents

3.5 *Detergency*:

Whereas this test has been recommended in the I.S; 4955 – 2001 but not even a single company that manufactured the tested powders conducted this test to satisfy the consumer confidence. Most probably owing to the high cost of instruments involved in the test, viz., terg—O—tometer and photoelectric reflection meter, the test was avoided. Moreover, the manufacturing companies appear to be of the general view that a common consumer is not concerned with such type of tests.

3.6 *Ash built up*:

In the opinion of authors of this paper, the recommended use of *ash build up* test in I.S ; 4955 – 2001, is hardly of any cognitive value. Also, not even a single company that manufactured the tested powders tried to conduct this test. Instead of this test, the test for " % of matter insoluble in water" as was in-force earlier in I.S ; 4955 – 1982, was more cognitive ; hence, it deserves to be restored.

3.7 *Packaging:*

According to various EPAs, the laundry detergents are marketed in plastic packets which mostly happen to be non-biodegradable and non-recyclable. The big volume of detergent packaging generates heaps of plastic rubbish which creates an enormous environmental impact. The European branch of the International Association for Soaps, Detergents and Maintenance Products launched an industry-wide initiative in the year 2009 to substantially reduce the size of detergent powder packaging by manufacturing smaller packages filled with highly concentrated detergent powders. The industry association, however, pointed out that for making such a packaging-reduction strategy successful, the consumers must first of all carefully read the printed labels and then make a habit to proportionately cut down on the quantity of detergent powder to be taken in a bucket. This is because, in the new perspective, significantly less quantity of the detergent powder would be required for the same cleaning efficiency of the powder as observed before because of the of the adoption of new

concentrated formula strategy. If this initiative also comes into practice in a vast country like India, the problem of creation of huge-sized plastic heaps in the streets can also be drastically reduced.

4.0 Conclusion:

Following the completion of research work on detergent powders, the authors of this paper have come to the conclusion that the multi-thousand crore detergent powder industry of India, although is thriving very-very well, but quality-wise it is not being controlled by any of the quality-control agencies, like Bureau of Indian Standards (BIS). None of the branded detergent packets tested by us showed ISI mark issued by the BIS. Also, none of the packets showed any of the characteristics enlisted in I.S.: 4955 – 2001, viz., active ingredients, total phosphates, sodium tripolyphosphate (STPP), active alkalinity, % detergency, and % ash built-up. It is concluded that chemical composition and quality of detergent powders manufactured in India is controlled by the manufacturers' own whims and fancies, and not by BIS specification. On the contrary, BIS specification itself is plagued by impractical test characteristics which are also ignored by all the manufacturers, and consumers are also totally unaware of all these. Further, from the standpoint of addition of very limited quantity of slush-creating insoluble mineral matter in the detergent powder, the older specification, I.S.: 4955 – 1982 (made redundant by the BIS), was much better environment-friendly than the currently applicable newer specification, I.S.: 4955 – 2001. For reducing pollution in water bodies, the various state pollution control boards of India should also recommended to the manufacturers for avoiding addition of phosphates.

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References:

1) Azizullah, A., Richter, P., Jamil, M., and Häder, D. P. (2012): Chronic toxicity of a laundry detergent to the freshwater flagellate, Euglena gracilis. *Ecotoxicology*. 21(7):1957-64..
2) Bajpai, D. and Tyagi,V. K. (2007): Laundry Detergents: An Overview. *J. Oleo. Sci.* 56 (7) 327-340.
3) Chaturvedi, V. and Kumar, A. (2010): Bacterial Utilization of Sodium Dodecyl Sulphate. *International Journal of Applied Biology and Pharmaceutical Technology.* 1:1126-1131.
4) Hill, Cindy (2010): Environmental Impacts of Detergents. http://www.livestrong.com/article/151779-environmental-impacts-of-detergent/East African Standard for synthetic laundry detergents for household (EA No. 127-2011).
5) Fried, S., Mackie, B. and Nothwehr, E. (2003): Nitrate and phosphate levels positively affect the growth of algae species found in Perry Pond. *Tillers* 4: 21-24.
6) Furman, N. H. (1962): Standard Methods of Chemical Analysis Volume 1- The Elements, 6th ed. D. Van Nostrand Company INC., New York.
7) Ghoochani, M., Shekoohiyan, S., Mahvi, A.H., Haibati, B. and Norouzi, M. (2011): Determination of Detergent in Tehran Ground and Surface Water. *American-Eurasian J. Agric. & Environ. Sci.* 10 (3): 464-469.
8) Ghose, N. C., Saha, D. and Gupta, A. (2009): Synthetic Detergents (Surfactants) and Organochlorine Pesticide Signatures in Surface Water and Groundwater of Greater Kolkata, India. *J. Water Resource and Protection.* 4: 290-298
9) Greenberg, A. E., Clesceri, L.S., Eaton, A. D. and Franson, M.A.H. (1992): Standard Methods For The Examination of Water and Waste Water 18th ed., American Public Health Association, Washington, D.C. U.S.A.
10) Hidayat, N. (2011): Optimization of pH, temperature and agitation rate on biodegradation of lipids and detergents in food wastewater by Bacillus sp N-09. *Journal of Agriculture and Food Technology*. 1 (5): 59-62.
11) Indian Standard (I.S: 4955-1982): Specification for Household Laundry Detergent Powders, Indian Standard Publication Institution, Manak Bhavan, New Delhi.
12) Indian Standard (I.S: 4955-2001): Specification for Household Laundry Detergent Powders, Bureau of Indian Standards, Manak Bhavan, New Delhi.
13) Indian Standard (I.S: 8401-1977): Specification for Alkyl Benzene Suphonic Acid (Acid Slurry), Indian Standard Institution, Manak Bhavan, New Delhi.

14) Ivanković, T. and Hrenović, J. (2010): Surfactants in The Environment. *J. Surfactants in The Environment.* 61: 95-110 12.
15) Kohler,J., (2006): Detergent phosphates: an EU Policy Assessment. *Journal of Business Chemistry.* 3 (2): 15-30.
16) K¨onnecker, G., Regelmann, J., Belanger, S., Gamonc, K, and Sedlak, R. (2011): Environmental properties and aquatic hazard assessment of anionic surfactants, Physico-chemical, environmental fate and ecotoxicity properties. *Ecotoxicology and Environmental Safety*. 74: 1445–1460.
17) Lee, G. Fred, (1973): Role of phosphorus in eutrophication and diffuse source control*. Water Research.* 1–2, Pages 111–128, DOI: 10.1016/0043-1354(73)90156-5
18) Nielsen, A. M. and Schaetz, T. (2012): Taking Steps Towards A Phosphate-Free Future. HPC TODAY Customers' Publications - *Industry Perspective Household And Personal Care Today* - N 2/2012 Page No. 13-16
19) Ogbulie, T. E., Ogbulie J.N. and Umezuruike I. (2008): Biodegradation of detergents by aquatic bacterial flora from Otamiri River, Nigeria. *African Journal of Biotechnology.* Vol. 7: 824-830.
20) Olkowska, E., Ruman,M. and Polkowska, Z. (2014): Occurrence of Surface Active Agents in the Environment. *Journal of Analytical Methods in Chemistry,* Volume 2014, Article ID 769708, http://dx.doi.org/10.1155/2014/769708
21) Olkowska, E., Polkowska, Z, and Namiesnik, J. (2011): Analytics of surfactants in the environment: problems and challenges. *Chemical Reviews.* vol. 111, No. 9, pp. 5667–5700.
22) Pattusamy,V., Nandini,N. and Bheemappa, K. (2013): Detergent and sewage phosphates entering into lake ecosystem and its impact on aquatic environment, *International Journal of Advanced Research.* vol.1, issue 3: 129-133.
23) Water treatment solutions Lenntech: Detergents Occurring in Fresh Waters. URL"http://www.lenntech.com / aquatic/detergents. htm". lenntech.com /aquatic / detergents.
24) Ying, Guang-Guo, (2006): Fate, behavior and effects of surfactants and their degradation products in the environment, *Environment International* 32: 417 – 431.
25) Zimring, C. A. and Rathje,W. L. (2012): Encyclopedia of Consumption and Waste: The Social Science of Garbage, car wash page No. 102, books. google.co.in/ books?isbn= 1452266670.