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Comparative Study of Detergents in India-A Step towards More Sustainable Laundry

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ABSTRACT

Commercially available detergents in the Indian market were studied for several quality parameters and environmental indexes. SDS and Triton X-100 were used as control. We have succeeded in compiling the comparative analysis data of all these brands w.r.t., pH, solubility, wetting performance, foaming ability, emulsions stability, surface tension, cleaning action, phosphate estimation, hemolysis assay, beet root assay and biodegradability test. The study aimed to collect all the relevant information with the objective to compare parameters for performance and eco-friendliness of the available commercial detergents and also help the consumer to make an informed choice of the detergent available in the Indian market and avoid being misled by manipulative marketing strategies that push out smaller and perhaps more polluting detergents.

Keywords: Biodegradability test, hemolysis cytotoxic activity, eco-friendliness, environmental profile and detergent quality parameters.

INTRODUCTION

The Indian detergent industry (1), (2) has been in rapid development since the 1980s. The production of these synthetic detergents in 1980-89 varied between 12 and14 lakh tons per annum which reached 13.35 lakh tons in 1990 and rose to 18.48 lakh tons in 1995. It was further projected that the production would increase to 25.50 lakh tons by the turn of the century indicating an extremely fast growth (3). Due to the increase in population, higher urbanization, spread of education and rising levels of income and consumption, the overall growth of the detergent market has been about 15% per annum. The market sources predict that the synthetic detergents (4), (5) would increase by the next decade at a growth rate of 25% per annum, with India becoming the world's fifth largest consumer market (6) by 2025 (value $1.5 trillion). Detergent market in India is segmented in three broad categories: Premium category; which includes Ariel, Surf Exel etc., Mid-priced category; which includes Tide, Wheel etc., and Mass market category; which include Nirma, Ghari, Fena, etc. Per capita consumption of detergents in India is 2.7 kg per annum, and is expected to grow at 7-9 kg per annum. Price is the most important factor in selecting a detergent for Indian consumer followed by brand image and cleaning action. With immense

competition in the detergent market, marketing and promotional activities of detergent brands pay least emphasis on creating awareness on environmental hazards and bio-toxicity effect of their products.
While India's Environment protection law in 1989 recognizes and categorizes phosphates as toxic chemicals (7), (8) but there is no regulation applicable to detergents. Lack of proper labeling of detergent constituents on detergent packages, rampant use of pollutant chemicals in Indian detergent industry, very little awareness about Green/ Bio-detergents (9)- (12) amongst consumers and decision makers and changing social scenario with less available time, water and energy, it is very pertinent that a proper study be conducted and these issues be addressed.

MATERIAL AND METHODS

Ten undergraduate students participated in the study. More than fifteen commonly used detergents were purchased from Kendriya Bhandar located at Delhi University, Utility Centre, North Campus, New Delhi and were studied for their several quality parameters and environmental indexes. SDS (sodium dodecyl sulphate) and Triton X-100 were used as control. Detergents brands selected for this study were Ariel antibac (*D-1*), Rin Refresh (*D-2*), Active Wheel (*D-3*), Surf Excel easy wash (*D-4*), Tide Plus (*D-5*), Henko (*D-6*), Genteel (*D-7*), Complete Ariel (*D-8*), Ezee liquid detergent (*D-9*), Surf Excel matic (*D-10*), Surf Excel blue liquid (*D-11*), 555 (*D-12*), Fena (*D-13*), Pearl laundry wash (*D-14*), Amway (*D-15*), Ghari (*D-16*) and Nirma (*D-17*).
All studies were performed at room temperature, in duplicates by two students, and mean of values obtained were taken.

Solubility: Solubility test (13) was done by taking 2% solution of each detergent in a conical flask. Each solution flask was heated in a water bath at 40^{o} C for 3 minutes. It was then left undisturbed for 2 minutes. The solution was filtered on pre weighed Whatmann filter paper 1 on Buchner funnel using vacuum pump. The filter paper with residue was carefully picked up and dried in oven at a temperature of 100 ^{0}C ±5 ^{0}C until a constant mass was obtained, and then final weight was taken.

pH: 0.1% solution of different detergents was taken. A pH meter was calibrated using buffers of pH 4, 7 and 10. Using the calibrated pH meter, pH of the each detergent was measured and recorded.

Surface tension: Surface tension was determined by drop number method (14) using Traube's Stalagmometer apparatus. 0.1% solution of each detergent was used. Water was used as reference.

Foaming stability test: Foam stability was measured using Ross and Miles (15) criteria. 10 mL of 0.1% detergent solution was taken in a test tube and shaken 10 times. The time for disappearance of 2 mm foam was recorded and compared.

Wetting performance test: Wetting criteria was measured by method of Draves (16). 1gram cotton thread was weighed and placed on the surface of 200 mL of 0.1 % detergent solution taken in a beaker. The time taken by the thread to completely sink to the bottom of the beaker was noted.

Emulsion stability test: The test was performed (17) by taking 5mL of 1% solution of detergent, to it was added 0.5 mL mustard oil and vortexed for 1 minute. Time was recorded when the solution becomes clear. Water was taken as control.

Hard water test: For hard water test (17), 15mL of 2 g detergent solution was taken in 3 test tubes. Test were performed by adding 10 drops of 5% $MgCl_2$, 5% $FeCl_3$ and 5% $CaCl_2$ in the 3 different above test tubes, and observations were recorded.

Biodegradability test: BOD_5 test was carried out with 100 mg/L of synthetic detergents (18), (19) in dark for 5 days at 20^oC. 5ml of inoculum of water from the local drain was added as microbial source. Diluent buffer with inoculum without the detergent was taken as control. The amount of oxygen taken up initially and after five days was measured using oxygen meter.

Beet Root Assay: This bioassay was performed by method given by Kirby et. al (20). 0.1 inch beetroot slices (uniformly sliced) were placed in water to wash off its excess color, replacing the water till the water became colorless. Then beetroot slices were placed in a test tube containing 5mL of 0.1% detergent solution and left undisturbed for 1 hour at room temperature. After 1 hour the absorbance was recorded at 535 nm using spectrophotometer. 1% HCl in methanol was used as reference for 100% disruption of the cells.

Cytotoxic Test: ***Hemolytic activity***:
RBC hemolysis assay was performed as given by Dehgham-Noudeh et.al (21).
Preparation of RBC: Heparinized blood was centrifuged at 4000 rpm for 10 minutes. The pellet was then resuspended in same amount of PBS and centrifuged again at 4000 rpm for 10 minutes the pellet obtained was resuspended in PBS and this step was repeated twice. The pellet was then suspended in same volume of PBS to get suspended RBC.
Test: Three eppendorfs were taken, in the control tube, 20 µL of RBC and 980 µL of PBS were added. As reference for 100% lysis, 20 µL of RBC and 980 µL of Triton X100 (1%) were added. For test, 20 µL of RBC, 880 µL of PBS and 100 µL of the detergent were added. Tubes were incubated at 37 ^{o}C for 15 min, centrifuged and absorbance was taken at 540 nm.

Phosphate content: Phosphate estimation was done by Fiske and Subbarow method (22).1 g of each detergent was weighed in individual flasks and 2-3 pumice stone pieces were put in them along with 25 mL 15% H_2SO_4. The solutions were kept in boiling water bath for 30 min and then allowed to cool. The final volume was then made to 100 mL with water. Three different volumes of each detergent (0.5 mL, 1 mL, 2 mL) were taken from the 100 mL solution in different test tubes. Deionized water, 2 N H_2SO_4, ammonium molybdate, KH_2PO_4 and ANSA (1-amino-2-napthol-4-sulfonic acid) reagent were then added to the tubes. Absorbance of the contents of tubes was measured spectrophotometrically and recorded.

Cleaning action: Various stains were applied on the cotton cloth and dried over-night. The clothes were pre-soaked for 15 minutes in 200 mL of 0.1% detergent solution and then stirred the cloth in the same solution by placing the beakers on magnetic stirrers for 15 minutes. The clothes were then washed with distilled water and finally dried.

RESULTS AND DISCUSSION

Comparative study of the detergents available in the market concluded the following results:

Solubility: Genteel (*D-7*), Ezee liquid (*D-9*), Surf excel liquid (D-11), Pearl laundry wash (*D-14*) and Amway (*D-15*) showed 100% solubility in water. 555 (*D-12*) showed the least solubility amongst the given detergents (Figure I). Hence all liquid detergents leave fewer residues so that less water is required in washing.

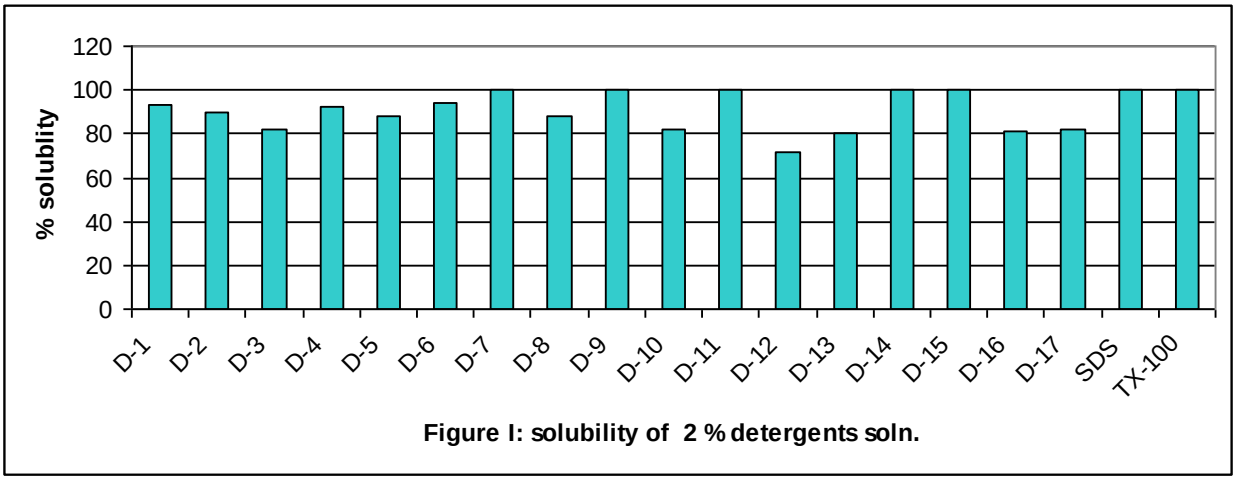


Figure I: solubility of 2 % detergents soln.

pH: It was observed that the solid detergents had an alkaline pH whereas the liquid detergents showed a nearly neutral pH (Figure II). Neutral pH detergents are safe on hands and are aquatic environment friendly.

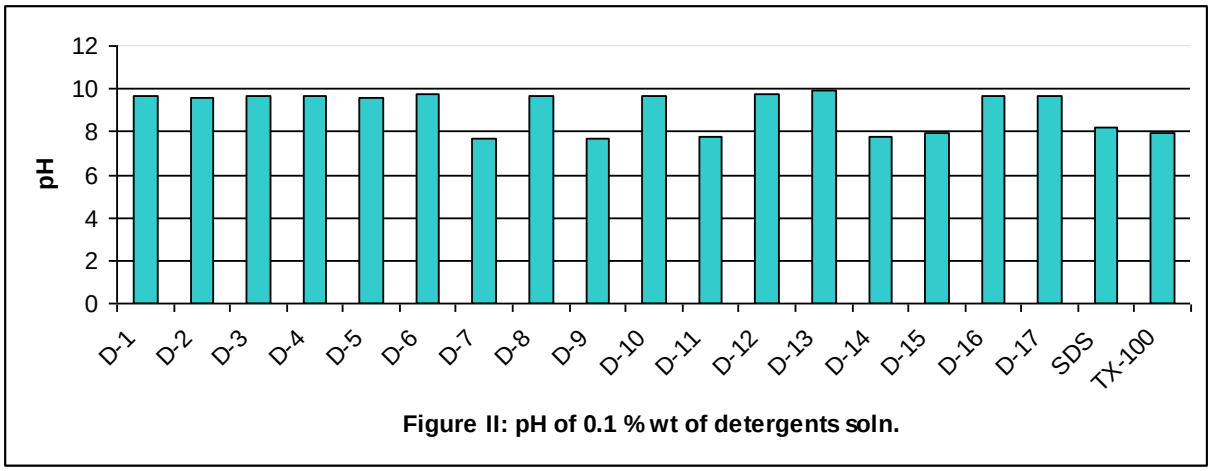


Figure II: pH of 0.1 % wt of detergents soln.

Surface tension: Decrease in surface tension is crucial for the effective working of a detergent. All the detergents showed a decrease in surface tension as compared to pure water (Figure III).

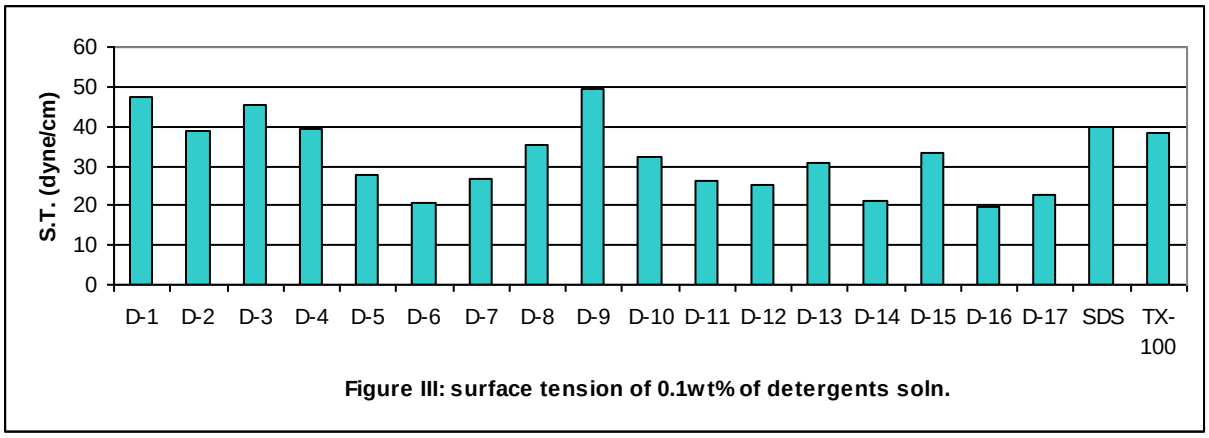


Figure III: surface tension of 0.1wt% of detergents soln.

Foaming test: For a good detergent, foam should form easily as well as collapse fast too so that less water is needed in washings. Ezee liquid (*D-9*) and Surf Excel blue liquid (D-11), take the most time for foam collapse, whereas Ghari (*D-16*), Nirma (*D-17*), Complete Ariel (*D-8*), Rin Refresh (*D-2*) and Wheel Active (*D-3*) take comparatively less time, hence are more water efficient (Figure IV).

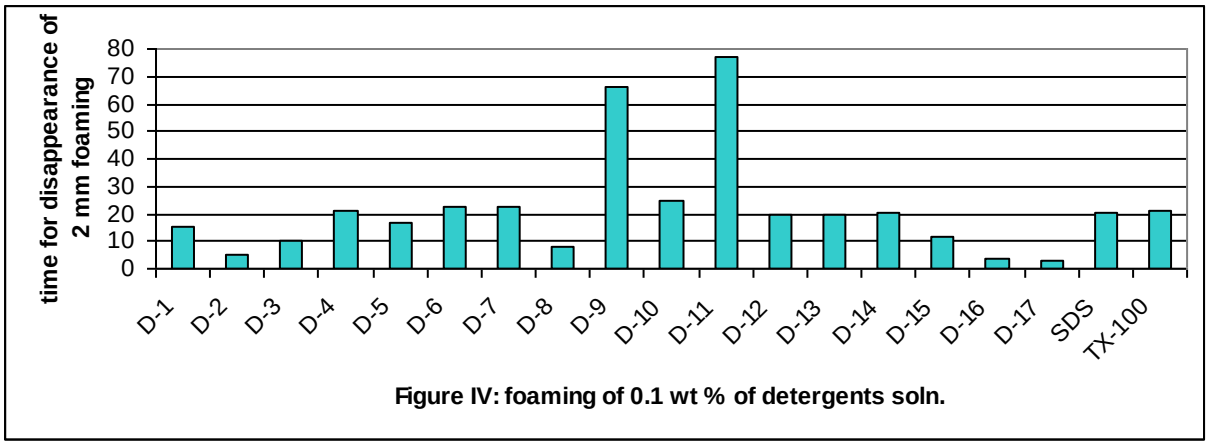


Figure IV: foaming of 0.1 wt % of detergents soln.

Wetting performance test: Less time the thread takes to completely soak and sink in the detergent solution better it is as a detergent. The thread takes least time to sink in TritonX-100 and maximum time in Rin refresh (*D-2*). Surf Exel matic (*D-10*), Surf Exel blue (*D-11*) and Amway (*D-15*) gave good wetting performance, therefore are more energy efficient (Figure V).

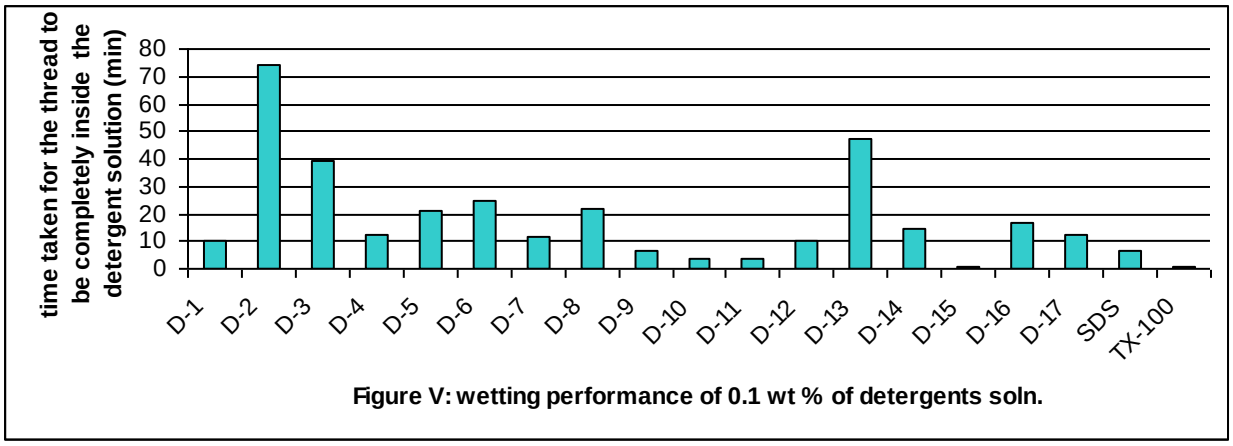


Figure V: wetting performance of 0.1 wt % of detergents soln.

Emulsion Stability: Good emulsion properties are crucial for a good detergent as emulsion formation is the basis of cleansing action. It was observed that Ariel antibac (*D-1*), Complete Ariel (*D-8*) and 555 (*D-12*) formed the most stable emulsions. Genteel (*D-7*) and Ezee (*D-9*) on the other hand formed least stable emulsions (Figure VI).

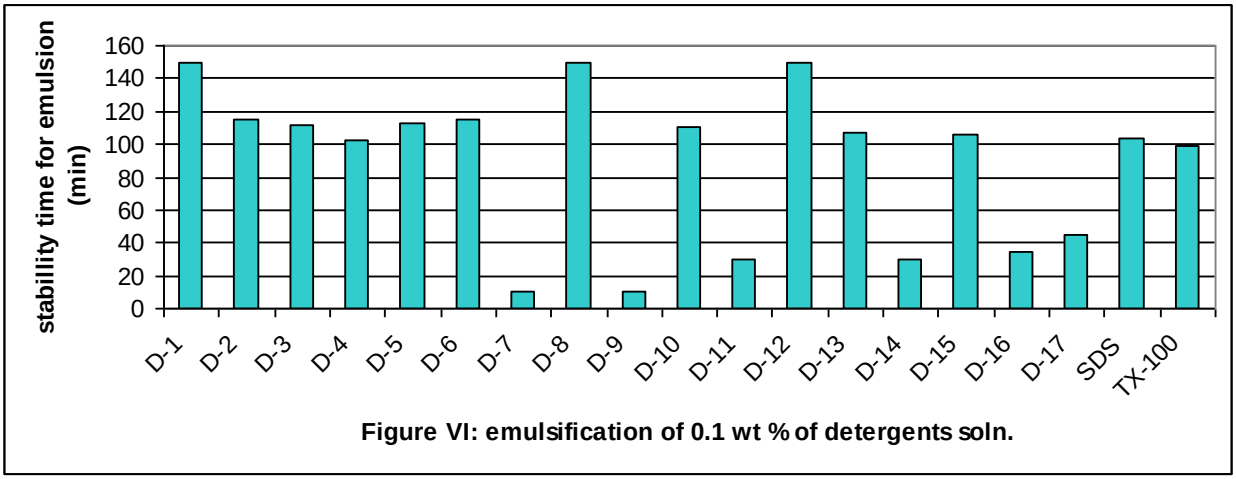


Figure VI: emulsification of 0.1 wt % of detergents soln.

Hard water test: A good detergent is one which does not form scum in and can be used effectively in hard water. Genteel (*D-7*), Surf excel liquid (*D-11*), Pearl's laundry wash (*D-14*) and Amway (*D-15*), showed no or very slight precipitate i.e scum formation (Figure VII).

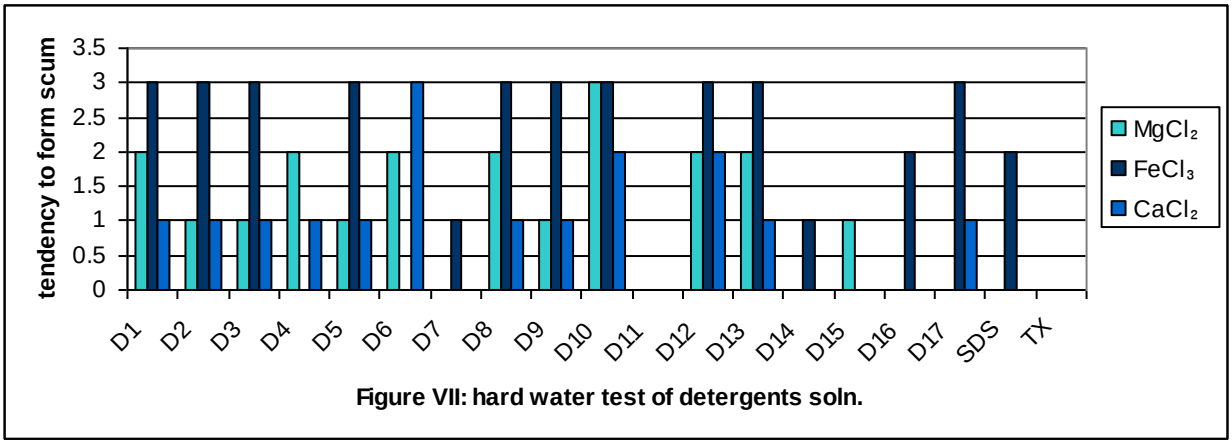


Figure VII: hard water test of detergents soln.

Biodegradability: All detergents showed more than 60% degradability in BOD_5 test.

Beetroot assay: Beetroot assay is basically a measure of toxicity of a detergent. Detergents can disrupt the cell membrane bilayer because of the amphipathic nature and cause a red pigment stored in vesicles of beetroot to be released. Surf excel matic (*D-10*) causes most membrane disruption followed by Henko (*D-6*) and Surf excel easy wash (*D-4*) and hence these are most toxic. Genteel (D-7), Ezee (*D-9)* and Wheel active (*D-3*) are least bio-toxic (Figure VIII).

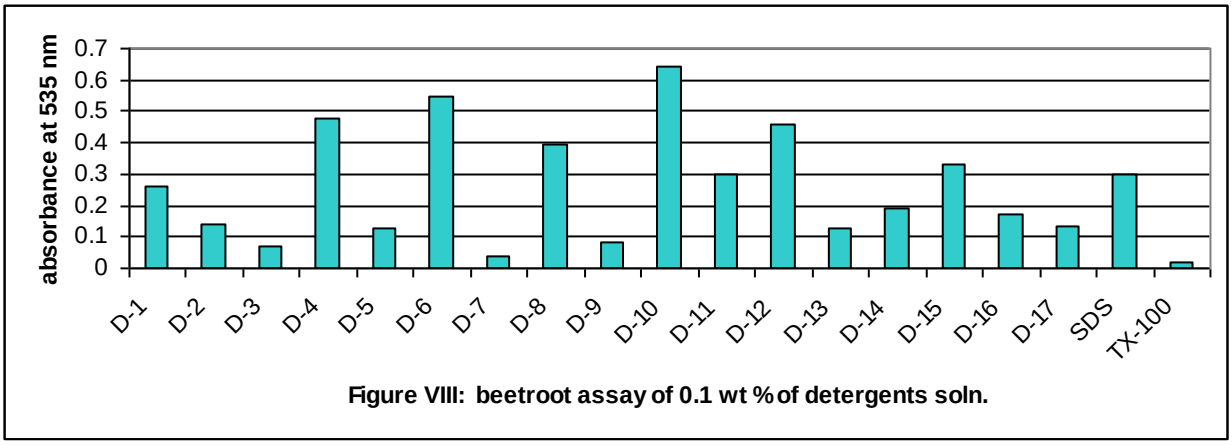


Figure VIII: beetroot assay of 0.1 wt % of detergents soln.

Haemolysis activity: Hemolytic activity is a measure of toxicity of a detergent. Being amphipathic, detergents can disrupt the RBC plasma membrane and release hemoglobin. Ezee liquid (*D-9*) and Nirma (*D-17*) showed least RBC lysis and hence are least toxic. Rin Refresh (*D-2*), complete Ariel (*D-8*), Surf Excel matic (*D-10*), Pearl's laundry wash (*D-14*) and Amway (*D-15*) show a 100 percent lysis showing they are the most toxic amongst the given detergents (Figure IX).

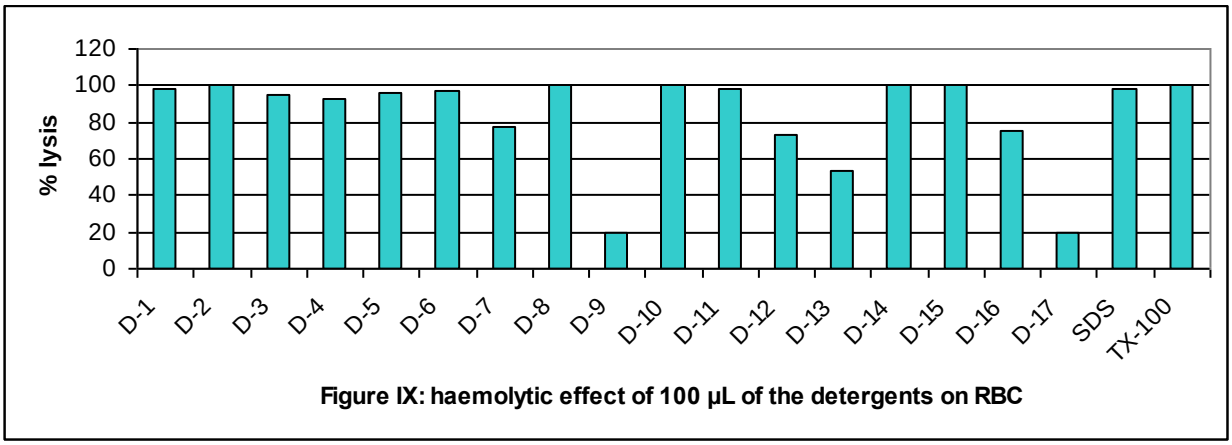


Figure IX: haemolytic effect of 100 µL of the detergents on RBC

Phosphate content: Phosphate is very deleterious to the environmental health. It is an indication of a non ecofriendly detergent. Henko (*D-6*), Genteel (*D-7*) and Ezee (*D-9*) have the most phosphate content and hence are least eco-friendly. Fena (*D-13*) and Nirma (*D-17*) show no phosphate content and wheel and Ghari (*D-16*) show very slight (almost negligible) phosphate content and hence these are eco-friendly (Figure X).

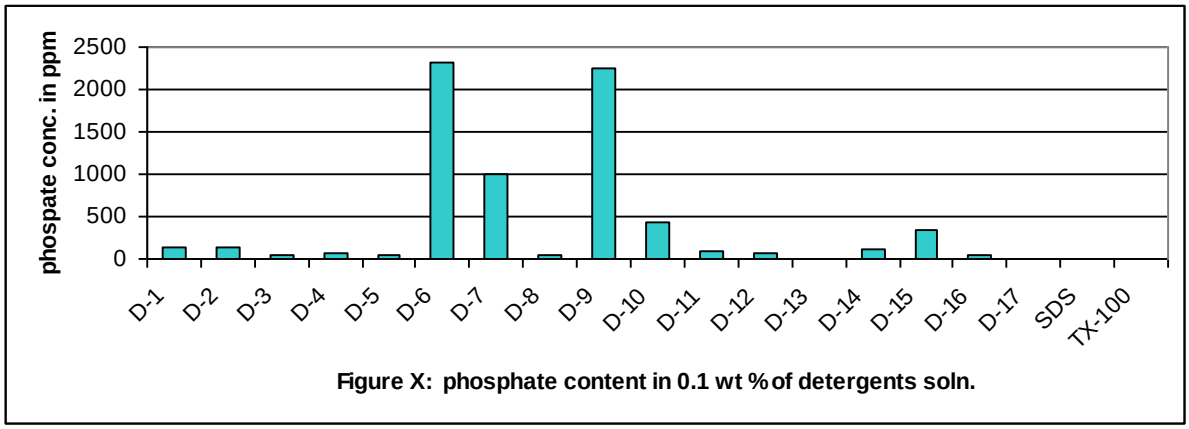
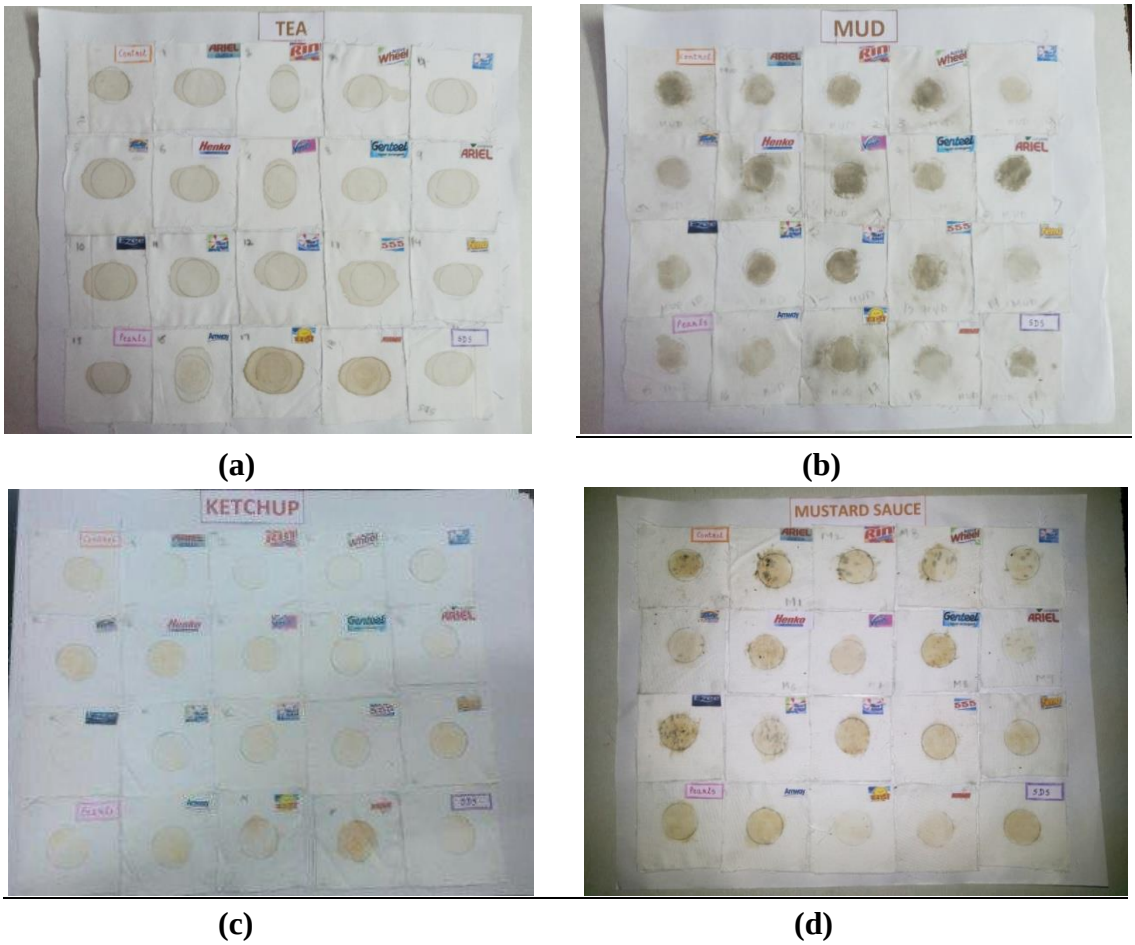


Figure X: phosphate content in 0.1 wt % of detergents soln.

Cleaning action: In terms of stain removal and brightness Surf Exel easy wash (*D-4*), Surf Exel matic (*D-10*), Ariel antibac (*D-1*), Rin Refresh (*D-2*) and Genteel (*D-7*) performed the best. Surf Exel easy wash (*D-4*), Genteel (*D-7*), Ezee liquid (*D-9*) and Wheel active (*D-3*) showed least colour fading (Figure XI).



(a) **(b)**

(c) **(d)**

Figure XI: Cleaning action of different detergents (*D-1* to *D-17*) on tea (a), mud (b), ketchup(c) and mustard sauce (d) stains.

CONCLUSIONS

The present study, for the first time in India carried out comparative analysis of more than fifteen brand of detergents in terms of their cleaning action, environment and bio-toxicity. The parameters tested were: pH, solubility, wetting performance, foaming ability test, emulsion stability, surface tension, cleaning action, phosphate estimation, hemolysis assay, beet root assay and biodegradability. From our relevant studies on commonly used detergent we concluded that many cheaper detergent like Ghari (*D-16*), Fena (*D-13*), and Nirma (*D-17*) were less bio-toxic with least hemolysis and more eco friendly with low phosphates , but found to be not so good in cleaning performance when compared to costlier detergents like Ariel, Surf excel, etc. These detergents provide a good cheaper alternative for majority of the population. Most liquid detergents were easy on hands when compared to powder detergents, they leave less residue , are easily soluble, and show low bio-toxicity but Henko (*D-6*), Genteel (*D-7*) and Ezee liquid (*D-9*) were found to be high in phosphates content. Our studies could not give us a clear winner in the present detergent market. But the study could serve as an initiative to make the consumer more aware, so as to demand more ecofriendly Green detergents with good cleaning action. This would pressurize the government to place more stringent regulations and the manufacturers to sell detergents which are less polluting, more ecofriendly, water and energy efficient with good cleaning performance. Informed public opinion would bring about stricter norms and regulations as in the western countries and bring better products in the market.

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