# EVALUATION OF ENVIRONMENTAL IMPACT AND BIODEGRADABILITY OF DETERGENTS: A COMPARATIVE STUDY

**DR. PREETI SHARMA, LECTURER IN CHEMISTRY**

**M.S.J. GOVT. P.G.COLLEGE, BHARATPUR (RAJASTHAN)**

***Abstract***

*This investigation was carried out with the purpose of determining the chemical and biological contributions made by the use of biodegradable detergents during the laundering process, which are thereafter released as pollutants into residential wastewater. In order to study representative parameters, such as DBO5, DBO21, DQO, phosphates, pH, salinity, dissolved solids, and surfactants, laboratory analyses were developed using water from the washing process and three different types of commercial detergents (A, B, and C) with different specifications in terms of their biodegradability. These analyses were performed with the water from the washing process. According to the findings, when non-biodegradable detergents were used, there was a significant rise in the concentration of surfactants, conductivity, phosphates, and dissolved solids in the wash water. On the other hand, there were found to be minor variations in the other chemical parameters. It's also possible to think that just two detergents managed to get the percentage of biodegradability indicated by the ratios DBO5/DQO and DBO21/DQO. This is something that may be examined. The non-biodegradable detergent is responsible for the largest concentrations of pollutants; this causes worry not only about the phosphate content but also regarding the high concentrations of surfactants; in addition, commercial usage of this detergent is the highest.*

***Keywords:****surfactants, biodegradability, detergents*

## INTRODUCTION

Household detergents Soaps, detergents, and other types of cleaning solutions are a significant contributor of both organic and inorganic compounds, including active components (surfactants), adjuvants, and additives. According to Ivankovi and Hrenovi (2010), these chemicals are released into the environment, often via urban and industrial effluent sewage systems, which leads to their widespread dispersion in the aquatic environment. Our dependency on these consumer goods is a direct result of the activities that comprise our typical day-to-day lives. Due to the emission of molecules such as surfactants, which are major causes of pollution in the water bodies of our nation, these formulations have developed into a concern for the environment, despite the fact that they have a great deal of practical application. These molecules have the characteristic of being amphiphilic, and they are made up of two structural sections or groups that are highly distinguished from one another. The first is a hydrophilic group (head group) that is polar and soluble in water, and the second is a hydrocarbon chain (hydrophobic tail) that is nonpolar and not very soluble in water (Ivankovi and Hrenovi, 2010). Since the Henkel company in Germany first introduced soap powder in the year 1907, the consumption of detergents and soaps has increased at an alarming rate. This has caused the global production of surfactants to reach the order of 16 million tons, which is approximately 44% of the production of detergents.

Since it is common to observe a blanket or layer of foam on the surface of water bodies, this has led the environmental authorities to take action in this matter. They have come to the conclusion that detergents, due to the different molecules that compose them, which are difficult to degrade due to their characteristics, affect the fauna and flora of aquatic ecosystems in an extraordinary way. Due to the large quantities of phosphorus that are included in tripolyphosphate, the primary component of detergent formulations, detergents are responsible for a number of negative effects on the environment, including eutrophication. In addition to this, they have the potential to raise the levels of chlorine and other organochlorine chemicals, of which some have the potential to be hazardous and carcinogenic (Villena and Serrano 2007).

Amphipathic molecules are those that have both polar (hydrophilic) and non-polar (hydrophobic) parts inside the same molecule. These molecules are known as surfactants. They have a tendency to lower the surface tension of the solution, which ultimately results in an increase in the surface active characteristics. Anionic surfactants, cationic surfactants, zwitter-ionic surfactants, and non-ionic surfactants make up the broad groups of surfactants. Anionic and cationic compounds always have a negative charge, whereas cationic compounds always have a positive charge. Non-ionic detergents do not have any kind of stable charge; rather, the atoms that make up these detergents are either weakly electronegative or electropositive. Zwitter-ionic refers to a molecule that carries two charges simultaneously. Anionic surfactants are the primary cleaning agent in the majority of laundry detergents; they are also able to remove oil and dust from clothing. On the other hand, cationic surfactants are utilized in detergents as fabric softeners and antistatic agents. Anionic surfactants are the primary cleaning agent in the majority of laundry detergents. These days, laundry detergents are the primary components that may be discovered in activated sludge and organic river sediments. In order for these substances to be released back into the environment, sewage treatment facilities need to degrade these components first. They will not be absorbed by the natural surfaces that are present in the waterways, therefore if they are not degraded correctly, they will end up in the water supply. This is because the water ways are not porous.

## Biodegradation

The process by which microorganisms in an aerobic or aerobic environment break down organic matter is known as biodegradation. This breakdown of organic matter occurs as a result of biodegradation. After being broken down by microorganisms, between 50 and 90 percent of these organic molecules are subsequently used to provide the energy that is required to keep life going. The remaining carbon content is put to use as a construction material for the various components of microbial cells, such as proteins, lipids, and others. When organic compounds are broken down by microbes, the end result is often mineralization products such as carbon dioxide, water, and mineral salts, as well as newly created biomass. The transformation of biological compounds into minerals requires oxygen from the surrounding environment, which ultimately results in carbon dioxide, water, and various mineral salts. In light of the findings, biological deterioration.

Since then, the detergent sector in India has been seeing significant expansion. The annual output of these synthetic detergents ranged from 12 to 14 lakh tons in, reaching 13.35 lakh tons in, and increasing to lakh tons in. In addition, it was predicted that output would climb to lakh tons by the turn of the century, which would indicate an exceedingly rapid increase. The global market for detergent has been expanding at a rate of roughly 15% per year on average as a result of factors such as a rise in population, increasing urbanization, the spread of education, and growing levels of income and consumption. According to the sources in the industry, the synthetic will expand within the next decade at a growth rate of 25% per year, with India being the fifth biggest consumer in the globe. The market for detergent in India may be broken down into three primary categories: The premium category, which includes brands such as Ariel and Surf Exel, among others; the mid-priced category, which includes brands such as Tide and Wheel, among others; and the mass market category, which includes brands such as Nirma, Ghari, and Fena, among others. It is anticipated that India would have the highest annual per capita usage of detergents in the world. The Indian customer places the most importance on price when choosing a detergent, followed by the image of the brand and the effectiveness of the cleaner.

**Biodegradation tests**

According to the Detergents Regulation, which provided the test methods, the accomplishment of a threshold level of 60% of the oxygen consumption or carbon dioxide generation in a period of 28 days was widely acknowledged as an indication of a very high level of ultimate biodegradation. This was the case since the threshold level indicated a very high level of biodegradation. According to the Detergents Directives, the amount of primary biodegradation of surfactants, measured as the removal of the parent chemical, is significantly higher than the 90% pass level. On the other hand, the requirement for 60% mineralisation is significantly more stringent than the current requirement for 90% primary biodegradation, which offers a significantly higher level of environmental protection.

In order to ascertain the main biodegradability of surfactants, a battery of experiments is carried out. The shake culture test, the semicontinuous activated sludge (SCAS) test, and the continuous activated sludge (CAS) test are all required by regulation in several nations, including the Organization for Economic Co-operation and Development (OECD). The shake culture test is used to determine the state of surface water, while the SCAS and CAS tests are used to promote the biodegradation process that takes place in the municipal sewage treatment facility. In order to get an idea of how organic molecules interact with their surroundings, a variety of different ultimate biodegradability studies have been carried out. Non-specific metrics like BOD/COD, CO2 evolution, and carbon removal are used to quantify the decomposition of organic compounds. In OECD, the following tests are specified: the closed-bottle test, the modified OECD screening test, the modified AFNOR test, the modified STRUM test, and the modified MITI test. The many biodegradation tests for surfactants have been shown thanks to the hard effort of so many individuals.

Because of the competitiveness in the market for detergents, the marketing and promotional efforts of detergent companies place the least amount of attention on raising knowledge about the environmental dangers and bio-toxic effects of their products. Although India's Environmental Protection Act of 1989 identifies and classifies phosphates as harmful compounds, there is no regulation that applies to detergents. This is despite the fact that the Act was passed in 1989. Because of a lack of proper labeling of detergent constituents on detergent packages, the rampant use of pollutant chemicals in the Indian detergent industry, very little awareness about Green/Bio-detergents amongst consumers and decision makers, and a 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. It is also very pertinent that these problems be addressed.

## OBJECTIVES

1. The Study Evaluation Of Environmental Impact And Biodegradability.
2. The Study That Only Two Detergents Obtained The Percentage Of Biodegradability.

## RESEARCH METHODOLOGY

In order to choose the detergents, we looked at their claim that they were biodegradable goods, as well as their composition and how much demand there was for them to be used for doing laundry. We also took into consideration the frequency with which detergents are used in residential homes. The features of the several detergents that were chosen for the study project are outlined in Table 1. When applying for sanitary registration, detergent manufacturing businesses are required by Resolution 1974 (2008) to declare the percentage of surfactant that is contained in the formulation of the detergent. Because of this requirement, the composition of detergents B and C only makes a general mention of the surfactant.

The selection of Detergent A was based on the fact that it is equipped with the exclusive and cutting-edge BIOQUEST FORMULATM technology, that it includes components derived from natural sources, and that, according to the manufacturer, it contains cleaning agents obtained from natural sources. It is also recognized by the Designed for the Environment (DFE) program and Protection Agency (EPA), does not contain phosphates, chlorine, or other abrasive acids, provides high performance due to its concentrated and environmentally safe formula due to the fact that it is biodegradable and dermatologically tested, and due to these characteristics, it serves as a model of analysis for the research project. The assertion that detergent B is an environmentally friendly product was one of the factors that went into our decision to use it. Another factor was the contribution of surfactants to the process of removing grime in the presence of phosphorus. The decision to go with Detergent C was made owing to the fact that it is a widely used detergent in homes due to its low cost and simple availability as a result of the distribution logistics of the firm that makes detergents. It is possible, based on its usage in volume, to predict that the primary source of pollutant loads to the discharge receiving systems is this substance, which includes surfactants.

**Determination of Biodegradability**

Standardized techniques based on Standard Methods were used in order to calculate the Biochemical Oxygen Demand (BOD), which determines the relative oxygen needs of the samples for a defined incubation time (5 and 21 days) at a particular temperature. This was accomplished by using standardized processes. Before and after the incubation, dissolved oxygen (DO) concentrations were determined, and the BOD value was determined by subtracting the initial DO concentration from the final DO concentration. A measurement of the oxygen equivalent of the content of the samples that are sensitive to oxidation of matter using potassium dichromate as an oxidant in the presence of sulfuric acid and silver ions as a catalyst was used for the determination of Chemical Oxygen Demand (COD). This was accomplished by utilizing potassium dichromate as the oxidant. The aqueous solution was heated in a closed reflux system for two hours at a temperature of 150 degrees Celsius. After then, the quantity of dichromate that had not yet reacted was calculated by titrating it with an iron(II) solution. The difference in the amount of dichromate that was originally added and the amount that was discovered after oxidation was used as the basis for the calculation of the Chemical Oxygen Demand.

The processes described in Standard Methods (Federation and Association, 2005) served as inspiration for this approach as well. The ASTM D standard was utilized in the process of determining the percentage of environmental biodegradability. This standard is based on the ratio between the COD (Chemical Oxygen Demand) and BOD5 (Biological Oxygen Demand) of the test samples for 21 days. This ratio is used to evaluate the biodegradability of the product through biological action (bacteria) and biochemical action (oxidation). If the BOD/COD ratio in 21 days is more than 60%, then the detergents that are examined will be declared biodegradable (Gender Cevallos and Ramrez, 2005). This criteria determines whether or not a material is biodegradable based on the ratio of BOD to COD.

**Physical-Chemical Parameters**

Methylene blue active substances were determined with the SAAM parameter for the formation of an extractable ionic pair in blue chloroform by the reaction of cationic methylene blue and an anionic surfactant of the detergent using the analysis method established in the Mexican Official Standard NMXAA039-SCFI-2001 (Pereza and Delgado-Blas, 2012). This reaction was carried out by reacting cationic methylene blue with the anionic surfactant of the detergent.

The ability of the water to conduct electricity served as the basis for the relevant study that was performed in order to assess the salinity of the water. Therefore, the salinity of water may be approximated by using a conductivity meter to measure the electrical conductivity (EC) of the water. Since salinity is influenced by temperature, in order to ensure that comparisons are accurate, the electrical conductivity was represented in relation to a reference temperature of 25 degrees Celsius. Other factors that influence the determination of the established parameters were analyzed in order to determine the correlation with the biodegradability of the detergents. These other factors include pH, orthophosphates, salinity, and dissolved solids, and all of these analyses were carried out by an independent contracted laboratory. Samples of biodegradable and non-biodegradable detergents were measured using the same protocol that was described above for the biodegradability and physical-chemical parameter analyses. Additionally, the dosages were checked to ensure that they were comparable according to the amount of use that was recommended by the detergent manufacturers.

## DATA ANALYSIS

**Ratio of Biodegradability DBO21/DQO**

The proportion of biodegradation may be determined by calculating the BOD/DQO ratio. This ratio illustrates the behavior of the ratio of the biochemical oxygen demand to the chemical oxygen demand and its ratio after 21 days have passed. This ratio represents the equivalent biodegradation percentage, and according to ASTM 2667 (Gender Cevallos and Ramrez, 2005), the detergents that are tested will be declared biodegradable if the ratio is more than 60 percent.

The fact that Detergent C is the least likely to be broken down by biological processes is reflected by the fact that it can be broken down most easily through chemical processes. This is due to the fact that it has a higher oxygen content than the substances that are broken down through biological processes, and microorganisms are unable to break down chemical concentrations. This also validates the biodegradation findings that were computed before, which indicate a greater degree of contamination owing to the oxygen demand needed by the water to decompose the organic matter content, including that which is essential for biological degradation. This is because biological degradation requires oxygen.

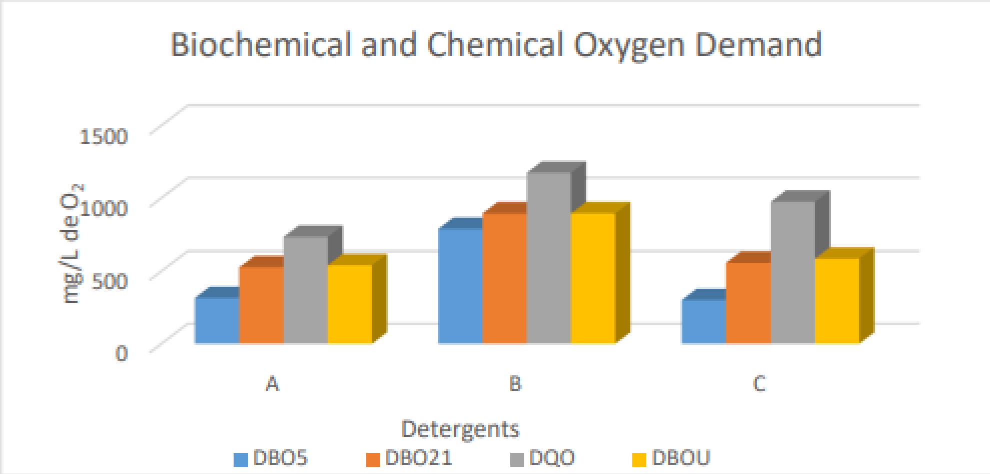


**Figure 1. DBO5, DBO21, DBOU Y DQO**

The values of nbDBO determined in proportion to the concentration of BODu in the COD show that the nonbiodegradable organic matter is much greater in detergent C (39.87% nbDBO), in comparison to detergent A (26.12% nbDBO), and detergent B (23.87% nbDBO). According to the percentages of nbDBO, detergent C is only capable of biologically degrading around 60 percent of the sample, and the remaining 40 percent is made up of organic matter that the microorganisms in the sample are either unable to ingest or cannot biodegrade. These high concentrations of COD, as a result of their oxidation, in turn generate a higher concentration of CO2 and CH4 from the decomposition of organic matter. This is because the microorganisms need oxygen in order to fully oxidize the organic matter to CO2 and H2O, which results in a higher concentration of greenhouse gases. The values of detergents A and B obtained from the COD/BOD5 ratio for the wastewater that was analyzed show that they may be treated by biological treatment such as activated sludge or lagooning systems in order to lower the amount of pollutant that is present in the water.

The electrical conductivity that was contributed by the detergents can be linked to the ions that are present in their composition as well as the concentration of dissolved salts in the water. When taking into account the total number of ions that were present in both the water and the detergent, there was a significant contribution made by the detergents that were examined. According to Lechuga (2015), there is also the possibility of a contribution coming from the surfactants that are present. These surfactants have particular unique characteristics that change depending on the concentration of the solution. These contributions are created by ions that are present in the composition of each of the detergents, and among these ions are also those that are provided by the dirt from the laundry. These contributions may be included in the overall total. It is possible to see in Graph 2 how significantly different the conductivity results of the three detergents are from one another.

According to the reports, detergent C has the greatest concentration of both conductivity and salinity, indicating that it also has the largest number of ions present. In addition, it is shown that the outcome of using detergent C is three times greater than the outcome of using detergent A, and nearly twice as high as the outcome of using detergent B. Due to the fact that Detergent C has a larger concentration of hydroxyl (OH-), which is represented in the pH findings (see Table 6), its conductivity is higher as a consequence of the values supplied by this ion (199 units). The values of the other common ions range from 40 to 80 units, which demonstrates that this detergent's composition has a larger concentration of cations and anions that contribute to the outcome of this conductivity test.

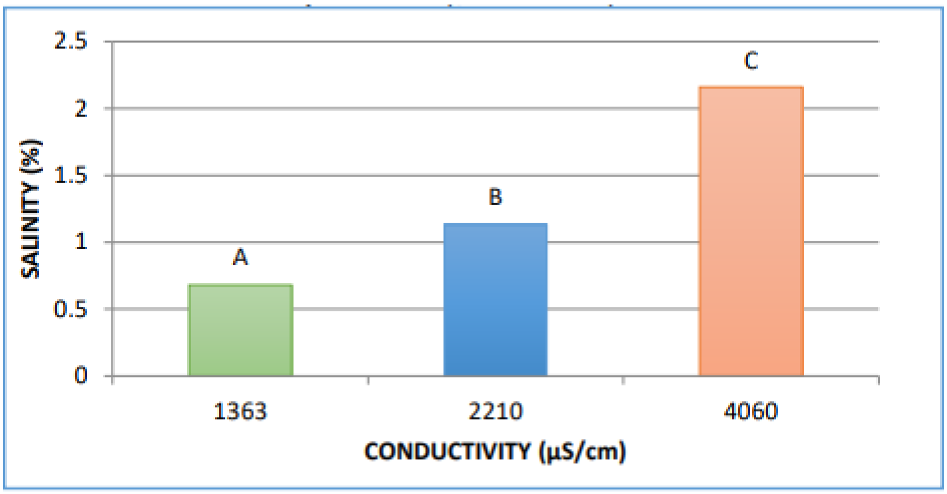


**Figure 2. Salinity/Conductivity Ratio**

The values that are obtained can cause an alteration in the conductivity of the environment, which can result in an increase or decrease in the levels of salts that are present. This will have a negative impact on the metabolic capabilities of organisms and even change the type of ion (for example, the exchange of potassium for sodium), which can be harmful to aquatic life if their biological processes are unable to adapt to the changes that are occurring. - Total Suspended Solids (also known as TSS) - Conductivity Although there are no reliable data available on possible health effects associated with the ingestion of TSS present in drinking water and no reference value that is based on health effects is proposed, detergent C, which shows a higher conductivity value and also indicates a higher content of salts than detergents A and B, shows a higher presence of TSS. According to WHO (2013), the presence of high quantities of TSS in drinking water might make it an unpleasant experience for consumers.

The quantity of detergent that was applied was calculated based on the concentration of the detergents and the references provided by the manufacturers; this had a significant role in determining the results that were obtained. In detergent A, owing to its concentration, 12 g was added, however in detergents B and C, it was 36 g, which implies that in the later two there is a bigger presence of ions that are part of the conductivity analysis, and in their correlation, a higher TSS was observed as indicated in the findings. Detergent A's concentration required that just 12 g be added, whereas detergents B and C required that 36 g be added. Due to the fact that conductivity is an analysis performed in an aqueous solution, the concentration of dissolved particles is directly proportional to conductivity; hence, the greater the conductivity, the higher the concentration. An approximation of the information presented above is given in formula 1, in which for the theoretical calculations necessary for the comparison of the analyses that were provided, FC=0.64 was used as FC=0.64 since it was determined by the manufacturer of the measurement equipment.

## CONCLUSIONS

Both Detergent A and Detergent B were found to have a BOD21/CBD ratio that was more than or equal to 60%, which indicates that they are both capable of biodegradation as determined by the results of the test conducted in accordance with the ASTM standard. In light of the COD/BOD5 ratio, both Detergent A and Detergent B fall within the biodegradability limits. Their respective values of 1.6 and 2.5 are lower than 3.0, which indicates that they are capable of breaking down into their component parts. The results showed that Detergent C did not meet the requirements to be declared biodegradable since it had a greater value for the COD/BOD5 ratio (3.5) but a lower value for the percentage of BOD21/BOD ratio (56%). The biodegradability results are in agreement with the specifications of the manufacturers of detergents A and B (see Table 1), in that the first one claims to be biodegradable and the next one is referred to as an ecological detergent. However, the ingredients of detergent C, which include surfactants and phosphates, do not show any environmental sensitivity actions, nor do they contain any technologies with biodegradable products to mitigate their effects on water bodies. The findings that were achieved by the three different detergent products, with regard to COD and pH, do not meet with the maximum allowable limit value of point discharges of residential wastewater that is outlined in resolution 631/2015. This is the case for all three detergent products.

## REFERENCES

1. Divya Bajpai, VK Tyagi. Surface-Active and Performance Properties of Cationic Imidazolinium Surfactants Based on Different Fatty Acids, Surface Review And Letters (Srl), 15(4), 2008, 361-367

2. Matthew J Scott, Malcolm N Jones. The Biodegradation Of Surfactants In The Environment, Biochimica Et Biophysica Acta (Bba) - Biomembranes, 1508, 2000, 235–251.

3. F Hosseini, F Malekzadeh, N Amirmozafari, N Ghaemi. Biodegradation Of Anionic Surfactants By Isolated Bacteria From Activated Sludge, International Journal Of Environmental Science & Technology, X 4(1), 2007, 127-132

4. WE Gledhill. Screening Tests For Assessment Of Biodegradability Test; Linear Alkyl Benzyl Sulfonate, Applies Microbial 30, 1975, 922-929.

5. Prasanna K Mohan, George Nakhla, Ernest K Yanful. Biodegradability of Surfactants Under Aerobic, Anoxic and Anaerobic Conditions, Journal of Environmental Engineering, 132, 2006.

6. Pt Sharma, S Bhattacharyya, Verma Vishal, Kalyan RK, Kumar Vijai, Pandey KN, M Singh. Studies on Isolation And Identification of Active Microorganisms During Degradation of Polyethylene/Starch, Central Institute of Plastics Engineering And Technology, Lucknow, India

7. RD Swisher. The Analytical Methods. Surfactants Biodegradation, 1970, 39-47.

8. [8.] DR Karsa, MR Porter. Biodegradability of Surfactants, Isbn: 978-94-010-4588-9, 978-94-011-1348-9,1995,1-27.

9. J Steber, H Berger. The Biodegradability Of Anionic Surfactants, In: DR Karsa, MR Porter (Eds.), Biodegradability of Surfactants, Blackie Academic And Professional, 1995, 134–182.

10. P Schoberl, KJ Bock, L Huber. OkologischRelevanteDaten Von Tensiden In Wasch- Und Reinigungs-Mitteln,Tenside Surfactant Deterg.,25,1998, 86–98.

11. J Steber, P Wierich. The Anaerobic Degradation Of Detergent Range Fatty Alcohol Ethoxylates - Studies With14C Labelled Surfactants,Water Res.,21,1987,661– 667.

12. AM Bruce, JD Swanwick, RA Ownsworth. Synthetic Detergents And Sludge Digestion, J. Proc. Inst. Sew. Purif. Pt., 5 ,1996, 427–447.

13. K Lotzsch, A Neufahrt, G Täuber. Comparative Tests On The Biodegradation Of Secondary Alkane Sulphonates Using 14c Labelled Preparations, Tenside Surfactant Deterg., 16, 1979, 150–15

14. A Neufahrt, K Lotzsch, K Weimer. Radiometric Studies on The Biodegradation Of Secondary Alkane Sulphonates In A Model Activated Sludge System, Jorn. Comm. Esp. Deterg., Xi, 1980, 105–118.

15. P Gode, W Guhl, J Steber. Environmental CompatabilityOf Fatty Acid, Alpha-Sulfomethyl Esters, Fat. Sci. Technol., 89, 1987, 548–552.