

REDUCTION OF LAUNDRY WASTEWATER TDS BY USING MICRO NANO BUBBLE TECHNOLOGY

Submitted in partial fulfillment of the requirements of the award of
Bachelor of Engineering degree in Mechanical Engineering

By

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INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited with grade "A" by NAAC

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work Of **M R KRISHNA SAGAR** (Reg. No. **38150065**) and **Y P V S PAVANKUMAR** (Reg.No.**38150127**) who carried out the project entitled **“REDUCTION OF LAUNDRY WASTEWATER TDS BY USING MICRO NANO BUBBLE TECHNOLOGY”** under my supervision from November 2021 to May 2022.

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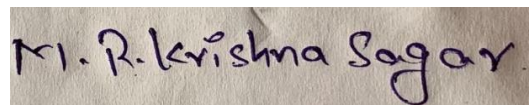
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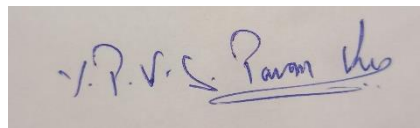
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DECLARATION

We, M R KRISHNA SAGAR (38150065) and Y P V S PAVAN KUMAR (38150127) here by declare that the Project Report entitled “REDUCTION OF LAUNDRY WASTEWATER TDS BY USING MICRO NANOBUBBLE TECHNOLOGY” done by us under the guidance of Dr. M. PURUSOTHAMAN, M.E, Ph.D., is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Mechanical Engineering.



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ABSTRACT

Clothes washers, as normal home devices, polish off a great deal of home-grown water. The functioning system of the customary clothes washer predominantly incorporates washing, flushing and parchedness. The flushing water has low contamination level, however the utilization is huge, representing over 70% of the complete water utilization, and the water asset use rate is low. Focusing on this issue, the water is mixed with the Thethankotai Powder and left for 24 hours to reduce the hardness of the water and also which will help in settling down of majority of dust particles and the water again under goes through the Micro Nano Bubble Technology Process which reduces some hardness of the water. Which we can later use for toilet and for the plantation by this we can as Through the standard fabric washing water treatment test, it is resolved that the contamination part in the clothing wastewater treated by Micro Nano Bubble Technology. Overall, Standard Washing Machine utilize 85.5 Liters of water per load, which, for the normal family that runs somewhere in the range of 5 and 6 burdens each week, amounts to 25222.5 Liters of water each year. From this process the TDS Result obtained are Tap water TDS is 1095, Laundry waste water TDS is 5225 and Laundry waste water containing Thethankotai Powder TDS is 3058. Purification of Laundry waste water contains Thethankotai Powder using nano bubble technology without air TDS is 1808 and Purification of Laundry waste water contains Thethankotai Powder using nano bubble technology with air TDS is 1562 as we can see the reduce of TDS value from 5225 to 1562 by the Micro Nano Bubble Technology.

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LIST OF SYMBOLS AND ABBREVIATIONS

TDS	-	Total Dissolved Solids
MNGB	-	Micro Nano Bubble Generator
μm	-	Micrometer
Nm	-	Nanometer
Ph	-	Potential Of Hydrogen
EC	-	Electrical Conductivity

CHAPTER-1

INTRODUCTION

1.1 BACKGROUND

Even though many old urban areas had seepage structures, they were primarily intended to deflect water from rooftops and asphalts. The seepage arrangement of ancient Rome is a unique model. Many surface conductors were connected to the Cloaca Maxima ("Great Sewer"), a massive arched channel that carried seepage water to the Tiber River. The Cloaca Maxima, built of stone and on a grand scale, is among the most well-known extant Rome architectural landmarks.

During the Middle Ages, progress in the field of urban trash and sewers was slow. The majority of squanders were effectively dumped into drains, where floods flushed them down the channels. Although privy vaults and cesspools were used, the majority of squanders were simply dumped into drains and flushed through the channels by floods. Latrines (water closets) were first introduced into residences in the mid-nineteenth century, but they were commonly associated with cesspools rather than sewers. Because cesspools were only intermittently cleaned and flooded as regularly as needed in heavily populated regions, neighborhood conditions gradually worsened. The danger to everyone's health became obvious. Cholera outbreaks in England in the nineteenth century were traced to well-water sources contaminated with human excrement from privy vaults and cesspools. It didn't take long for all storage tank rooms in the larger cities to be directly connected to the storm sewers. This routed sewage from early houses to nearby streams. Another concern occurred as a result of this: surface water contamination. Treatment of sewage has improved.

"The answer to contamination is weakness," it was once claimed. A typical course of stream self-cleansing occurs when little amounts of sewage are dumped into a flowing canal. Despite the fact that densely populated networks produce significant amounts of sewage, weakening alone does not prevent contamination. This necessitates some treatment or cleansing of wastewater prior to its removal.

Incorporated sewage treatment plants were first developed in the late nineteenth and early twentieth centuries, especially in the United Kingdom and the United States. Rather than just dumping sewage into a nearby stream, it was first put through a series of physical, organic, and compound cycles, which removed some or all of the contaminants. Similarly, beginning in the 1900s, new sewage-assortment frameworks were designed to separate storm water from domestic wastewater, preventing treatment plants from becoming overburdened during wetweather.

Growing public concern over environmental quality after the mid-twentieth century prompted more extensive and strict wastewater cleanup rules. There was a need for more intensive treatment. Pretreatment of modern wastewater, for example, has frequently become necessary to avoid hazardous synthetic substances from interfering with sewage treatment plants' natural cycles. In reality, wastewater treatment technology has progressed to the point that practically all toxins can now be removed from sewage. Nonetheless, because such high amounts of therapy were so expensive, they were rarely used.

Sewage treatment plants turned out to be big, complex offices that need massive amounts of energy to run. Concerns regarding energy saving became a more prominent component in the construction of new pollution control frameworks with the rise in oil prices in the 1970s. As a result, where practical, land clearance and subterranean sewage removal began to receive increasing attention. Such "low-tech" pollution control methods could be employed not just for energy monitoring, but also for successfully utilising nutrients and replenishing groundwater. To address the issue of financial water scarcity, the study presents a monetary technique for LWW treatment. Furthermore, addressing the critical LWW measurement taken each day in the review zone will decrease contamination of the removal locales & make them more effective for a number of purposes. Several current methods have been discovered, however only a handful are applicable to developing countries^{8,12,17}. Although sedimentation and filtration are being used to clean LWW, they only reduce pH, TSS, TDS, turbidity, and total hardness¹⁷.

There have been no changes in COD or biochemical oxygen demand (BOD), but iron content has increased by 93 percent. Regardless, the approach is effective and can only be utilized for the first flush of soiled garments¹⁷. Expulsion rates of suspended solids (SS), BOD, COD, absolute nitrogen, and all out phosphorus were 78 percent, 83 percent, 85 percent, 78 percent, and 86 percent, respectively¹⁸, in a skewed soil treatment framework with plastic froth plate soil with alumina and hydrated silica. When delivered from waste wood, bagasse fly debris, coconut-roughage carb, and peat¹⁹, biochar made by typical adsorbents is less expensive than activated carbon.

Furthermore, the exploration will be easier to utilize in other non-industrial countries due to the utilization of simple, locally available materials. Bio-scorch derived from local woodlands was judged a promising solution for assuring cost-effectiveness, according to this. Biochar was delivered at a regulated temperature range, such as 700 degrees Celsius^{20,21}, and was the most likely retentive for retaining produced natural carbon from wastewater. The morphological examination of bio-roast indicated a surface area of $>500 \text{ m}^2/\text{g}$, which is appropriate for wastewater pollutant adsorption.

Because teff straw is a staple item in Ethiopian households, much research has been undertaken on the naturally occurring and unrestricted adsorbent. Domestic and modern wastewater can be treated with treated straw at a fraction of the cost^{22,23,24}. Desta Mulu Berhe (2013) investigated the material originating treatment of untreated and treated teff straw adsorbents and discovered that they were expected adsorbents for Cr, Ni, and Cu removal²³. Tadesse et al., (2015), on either hand, showed great capability of agribusiness waste materials as adsorbents, using teff, wheat grain, almond shell, and coconut as adsorbents in their study. Tree sawdust and rice straw were used to remove Cr(VI) from calfskin processing wastewater quantitatively. The creators introduced the Langmuir isotherm ($R^2 = 0.9739$) and sort of semi request model ($R^2 = 0.9999$), revealing the technique as a suitable wastewater treatment method²². Wessie and Srivastava (2016) used scanning electron microscopy (SEM) to identify teff straw as a mesoporous material with a pore distance of 43.9 and a surface area of $30.5 \text{ m}^2/\text{g}$. This substance was employed to eject Cr(VI) metal.

In this review, a multi-boundary approach with a new multi-media mix was tried for textile wastewater treatment. Sand, bio-singe, and teff-straw are the three media limits used here study's multi hindrance all-encompassing approach. These three treatment steps will lower the possibilities of treatment failure, increase the amount of tainting evacuated at every stage, and improve the treatment interaction's overall competency. No previous research had looked into the recommended mix of detailed local available media, to the extent of the creators' knowledge and the below Fig 1.1shows.



Fig 1.1 Waste Laundry Water

Laundry (soaps, detergents, chlorinated and aromatic solvents, organic matrix, fats, grease, and oil) and inorganic (heavy metals, sand and soil dust, metal particles and particles) compounds in laundry wastewater make treatment difficult. Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), and Total Suspended Solid (TSS) levels are typically at 5000, 1300, and 1000 ppm, respectively. COD levels of up to 20,000 ppm have also been seen on occasion. Ordinarily, home, industrial, and hospital laundry waste water is investigated. in table 1.1

Table 1.1 Characterization of domestic, industrial and hospital laundries wastewater

Parameters	Industrial Laundry	Hospital Laundry	Domestic Laundry
pH	9 - 11	11.4 - 11.6	9.3 - 10
TDS, mg/L	420	456 - 800	400 - 6000
EC,S/cm	640 – 3000	808 - 2000	190 - 1400
TOG, mg/L	71.5 – 11790	25 - 26	8.0 -35
TH, mg/L CaCo3	44	53- 68	-----
TA, mg/L CaCo3	128	302 -375	83 - 200
TSS, mg/L	April -00	66 - 71	200- 987
Turbidity, NTU	40 – 150	87.9	14 - 400
Phosphate, mg/L	3.43	10.8 – 167	4 – 27.6
BOD5, mg/L	218 – 9810	87.9	48 - 1200
COD, mg/L	80 – 212, 000	477 - 876	375 - 415

- a. IDofthewellspringsofwater,methodofwashing,cleansersandfadeutilizedinchosen laundries
- b. Assessmentandassessmentofwastewatercreatedincommonlaundriesinthereview region
- c. Assessment of the capability of gathering, treating and reusing of clothing wastewater.

1.2 EQUIPMENT ANDMATERIALS

The laundry waste water have collected from the washing machine and by manual wash and the below Fig 1.2 and Fig 1.3 show the washing of clothes



Fig 1.2 Washing Machine



Fig 1.3 Manual Washing

Laundry is done both by machine and by hand. The following is the strategy that was used for a variety of tests:

1. A liter of freshwater was taken in a spotless can from the water source used to wash the clothes.
2. In addition, a liter of effluent from the washing system was collected and added to the collection container. When the material was washed twice, a liter of each wash wastewater was collected and added to the can containing the freshwater source, and a liter of the mix was collected and added to the can containing the freshwater source..
3. In addition, a liter of washing machine effluent was collected and dumped into the same container. When the item was flushed twice, a liter of each flush sewage was taken in a separate can, and a liter of the combination sewage was retrieved and put to the water and wash wastewater collection pail.
4. A liter of water, wash wastewater, and flush wastewater were thoroughly mixed in the collection container. Wastewater. The gathering container containing the combination of freshwater, wash wastewater and flush wastewater was blended completely.

In a plastic container, the garment's wastewater was collected. The friction drag of gas–liquid two-phase flow decreases as the fraction of MB in vertical pipe flow increases. Experiments with blowing MBs from the bottoms of huge ships are now confirming experiments to minimise friction drag ships.

1.3 FLOW RATE MEASURED

Flow measurement can be defined as quantification of the development of water in a given channel. Flow can be measured either by deciding the displacement and additionally Velocity of the water. Water meters ordinarily control measure and show absolute utilization in cubic meters, on either mechanical or electronic registers. Flow can be partitioned into two fundamental streams which are: Open channel flow and Closed course flow. Flow is controlled by utilization of valves at stretches to either to dial back, permit quicker flow or totally shut down the flow . Some water meters ordinarily fill both the role or making readings and controlling flow while others simply direct estimating as it were Meters for recycled water contain unique lavender register covers show that the water is non-consumable. Speed type meters measure the speed of move through a meter of a known interior limit. The speed of the stream can then be changed over into volume of stream for utilization. Since Multi-stream meters are typically exceptionally exact in little sizes they are regularly utilized for private and more modest business utilizes. Turbine meters are not so exact as stream meters and removal meters at low flow rates. A compound meter is utilized where high flow rates are important. Attractive flow meters are a speed type water meter, then again, actually they utilize electromagnetic properties to decide the water flowspeed.

1.4 OXYGEN DEMAND

Oxygen Demand (COD) of laundry wastewater , which means that the wastewater is increasingly toxic, so increase the

Further advances are required to solve the pricey NBs generating difficulties. More opportunities for developing cost-effective ways must be explored through engineering. For a better viewpoint, engineering exploitation should not only be focused on its feasibility generation, but also on application-oriented commercial process development is now weak and poorly related to MB and NB's basic physical chemistry and engineering science the evolution of their procedure As a result, it is expected that readers of this article would promote further research and analysis. building bioprocesses while relying on NB science as a foundation. NBW has uses in agronomy, where it promotes root growth while saving water and improving crop output and quality by synergistically enhancing water usage efficiency in irrigation. It may also hold promise for the development of low-cost biofertilizers to boost long-term soil nutrition. Liu and colleagues. The study also recommended that greenhouse produce quality be improved by subcontracting. In general, DO concentrations in biological wastewater treatment must be properly assessed to guarantee that microorganism growth is possible. Insufficient oxygen, on the other hand, causes biological processes to be disrupted or fosters anaerobic growth. Although a high DO concentration will not improve biological process efficiency, it will increase wasteful air pumping expenses. MNBs can enhance DO concentration and oxygen mass transfer rate, which speeds up the elimination of contaminants, according to Liu and Tang For oxygen microbubbles and microbubbles, the stagnation periods were 9300 and 9985 minutes, respectively, compared to 578 minutes for airMNB.

1.5 FUNDAMENTAL PROPERTIES OF MICRO NANOBUBBLES

For Water air pockets can be divided into three types: regular or micro bubbles, microbubbles (MBs), and nanobubbles (NBs). Full scale bubbles have a width of 100 m to 2m.

. These air pockets rapidly ascend to the outer layer of a fluid and breakdown. While microbubbles are more modest than large scale rises, with a measurement scope of $1\text{ }\mu\text{m}$ - $100\text{ }\mu\text{m}$, these air pockets shrivel in the water and afterward break up into it.

Conversely, NBs are minuscule gas bubbles that have a few novel actual properties that make them altogether different from typical air pockets. For the mostpart, NBs range $<1\text{ }\mu\text{m}$ in distance across nonetheless, the NBs that are $<100\text{ nm}$ in distance across arbitrarily float in what the future held and with a lower lightness can stay suspended in fluids for a lengthy timeframe and can change the ordinary qualities of water. Regardless of ensuing investigations, there are still discussions over NBs' size and their reality in arrangements under barometrical circumstance. As per old style thermodynamics hypothesis, NBs can't exist or be steady because of the constraint of span shape. For example, the little span of shape gives NBs a higher inner strain comparative with the outer tension, which prompts quick disintegration and the nano bubble shown in the Fig 1.4

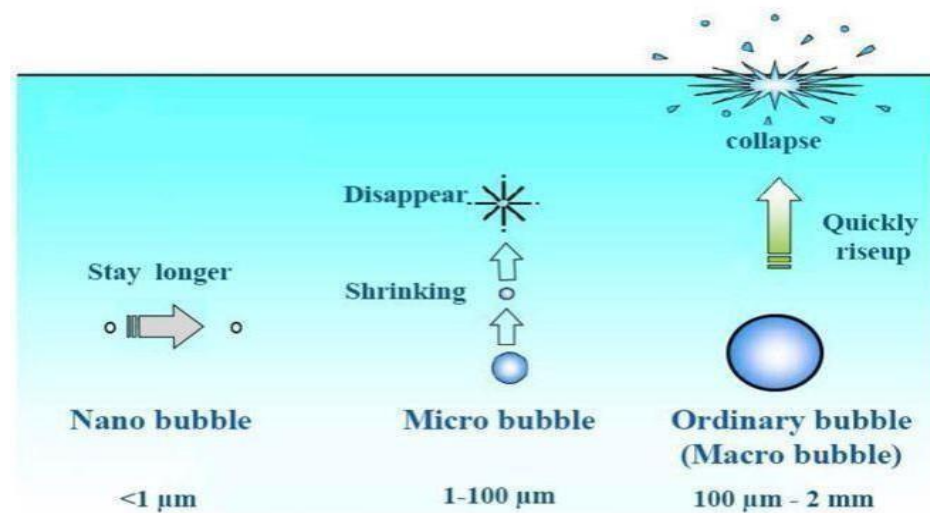


Fig 1.4 Nano Bubble

For example, a Nano bubble with a sweep of 100 nm has an inner tension of 1.5 MPa climatic strain in the surrounding water = 105 N m^2 and surface strain = 72 m N/m . This study's fundamental hypothesis is this

peculiarity is the more inner tension contains in the Nano bubble doesn't accomplish offset with the environment, which would definitely prompt the air pockets barging in an exceptionally brief time frame.

first detailed the presence of Nano bubble as brilliant and constant circles on a level surface. In any case, as of late different techniques have likewise been taken on for NB examination, for example, neutron reflectometry, X-beam reflectivity and quartz precious stone microbalance. One of the special properties of NBs is expressed to be their higher life span, which gives them a bigger contact point and longer presence time in the fluids first detailed the presence of NBs as brilliant and stable circles on a level strong surface, through nuclear power microscopy . In any case, as of late different techniques have likewise been taken on for NB examination, for example, neutron reflectometry, X- beam reflectivity and quartz preciousstone.

CHAPTER – 2

LITERATURE REVIEW

2.1 ZETA POTENTIAL OF MICRO NANOBUBBLES

Zeta The term "zeta potential" refers to the size of the attraction between particles and air pockets, also known as electrostatic repugnance. The life lifetime of a Micro nano bubble in a framework is determined by a significant attribute. 2013[1] Jia et al. The Malikowski condition is used to calculate the zeta potential. Ushakov et al 2010[2]; Han and Dockko 1998. MBs and NBs have a negative charge in the pH range of 2-12, depending on the type of gas given, and the zeta likely varies from 50 to 40 mV and 30 to 20 mV at an unbiased pH, respectively. The oversupply of hydroxyl particles (OH) in comparison to hydrogen particles (H⁺) at the gas-water interface does not guarantee a negative zeta potential Ohgaki et al 2010[3]. The specific adsorption of hydroxyl particles in the electrolytic arrangement is also linked to the charging instrument of NBs. Furthermore, the solidity of the NBs is strongly influenced by hydrogen retention at the water-gas interface, resulting in an impermeable, actively stable surface that makes it safer to disseminate Wang et al 2013[4].

2.2 MASS TRANSFER PROPERTIES

Creating and The proficiency of the cycle is not fully determined by the gas to fluid exchange rate in various gas-fluid stage duties; as a result, mass exchange is a framework's basic attribute Wilkinson and van Dierendonck 1990[5]. The mass exchange efficiency is determined by the size of the air pockets, their spreading speed, the gas-fluid hydrodynamics, the blend and separation surface-to-volume ratio, and their real property (Bouaifi et al. 2001[6]. The mass exchange pace of two is not totally fixed in stone by the coefficient of fluid gas mass exchange, surface region to volume proportion, and fixation inclination inside these stages, as shown by the gas retention two-film concept Whitman 1962; Bouaifi et al. 2001[7]. The gas-fluid mass transmission rate is calculated using the unsteady state technique Terasaka et al. 2011[8].

Estimation of the mass exchange coefficient of MBs in reference to various numerical models. Bredwell and Worden 1998 [9] proposed a novel methodology that said that the mass exchange coefficient is related to variables such as bubble size decline, which he theoretically addressed with a single MB of size 25 μm . Furthermore Ying et al. 2013 [10] also promoted a model to improve the mass exchange rate, which was linked to the rate of carbon dioxide exchange in relation to the size of the air pocket. As a result, Li et al. 2016[11] used a mixed reactor to study the mass exchange mechanism using a 50 μm MB. They discovered that mass fluid flow through the MB generator increased the temperature of the mass fluid, altering gas solvency, specifically for a smaller volume mass fluid. They used a temperature connection factor of 20 $^{\circ}\text{C}$ to calculate the mass exchangerate.

2.3 MICRO NANO BUBBLE GENERATION ANDTECHNOLOGY

MNBs are formed on the hydrophobic particles' outer layer. The configuration of MNBs can be triggered in a variety of ways, depending on inner or exterior variables (diamagnet 2015). Water bubbles are mostly formed by dissolving gas under pressure and providing gas while reducing pressure bubbles, which is a common approach. The device is largely made up of a water syphon, air blower, and air tank in this method. The water syphon exerts a certain tension in order to direct circulating water to the corroded fuel tank, while the air blower forces air into the corroded fuel tank. The supersaturated and broken up gas is caused by the high-pressure gas-water blending situation framed in the disintegrated fuel tank. shows a schematic outline of the generally utilized MNB generator is a schematic diagram of a commonly used MNB generator . Through a gas-disintegration tank and MNB generating spout, a syphon circles water in a simple acrylic tank. On the pull side of the syphon, air is injected into the circulating water and destroyed by a high-pressure framework. Because of the strain reduction at the spout, a vaporous period of MNB is formed from the water supersaturated with air. There are a variety of tactics associated with MNB age which examines various air pocket age standards and devices as shown in Fig2.1

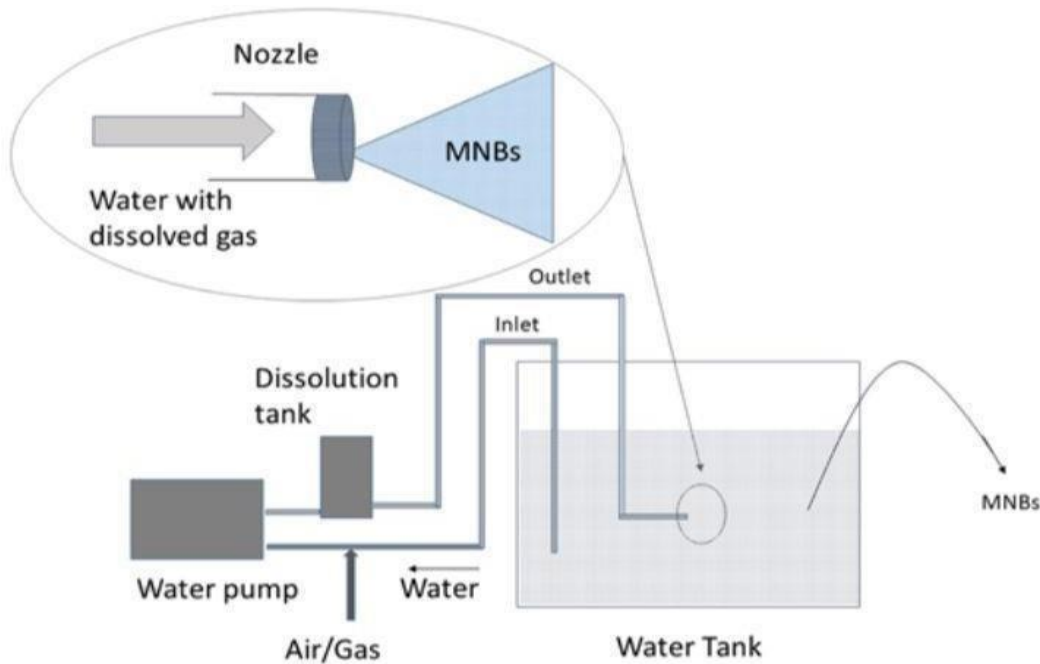


Fig 2.1 Micro Nano Bubble

Cavitation occurs when the liquid phase undergoes a phase transition as a result of extreme pressure loss under a critical value Wu et al. 2012[12]. Cavitation is usually caused either by transmission of ultrasonic or greater changes in a moving fluid (hydrodynamic cavitation) Ultrasonication Kim et al. 2000; Effinger & Wheatley 2004[13] and chemical reactions like electrolysis can also produce NBs.

The hydrodynamic cavitation mechanism is commonly employed to generate NBs by the Venturi-type generator Agarwal et al. 2011; Ahmadi & Durban 2013[14]. The Venturi system is made up of three basic components: input flow, tubular output flow, and tapered output flow Parmar & Majumder 2013 [15]. By raising the speed of the fluid in the converging portions of the narrow diameter pipe, the pressure in the Venturi tube can be reduced Fan et al. 2010a [16]. Liquid and gas are transferred concurrently through the Venturi tube to form bubbles in the Venturi-type generator system Parmar & Majumder 2013[17]. When pressurized liquid is pumped into the tubular component, the fluid flow into the tubular part increases.

the Cavitation occurs when the pressure in the cylindrical throat rises above the pressure in the input section Fan et al. 2010a[18].

The size range of NBs is much broader Ahmadi et al., Durban, 2013 [19]
The hydrodynamic cavitation mechanism produced NBs of 130–545 nm using a Venturi tube Wu and colleagues, 2012 [20] used hydrodynamic cavitation to make NBs with a diameter of less than 500 nm. 2005, Cho et al [21] used a palladium electrode and ultrasonication to produce NBs with an average diameter of 300–500 nm. Ultrasonication with octa-fluor propane gas produced NBs with an average diameter of 450–700 nm.

2.4 EFFECTS OF VARIOUS OPERATIONAL CONDITIONS ON BUBBLE SIZE

The article demonstrates that the transport and size of MNBs are dependent on the framework plan and many functional variables. For example, the tension variations across the spout architecture are largely responsible for MB division and growth. Because of the expansion in air thickness, the larger the air pocket size becomes as the strain increases; however, the size of MBs remains constant at tensions above 3.5 atm (de Rijk 1994)[22], whereas the size of NBs is still determined by factors such as hose size and type, pressure, and sonic power. Furthermore, certain gases have an effect on the presence season of NBs; for example, the presence of NBs can be detected for a long time when pure oxygen is present is utilized to create the air pockets, while on account of air bubbles, the presence time is just for under 1 [23] (Ushikubo et al. 2010). Using a gas with a larger subatomic weight increases the thickness of microbubbles, resulting in more modest air pockets (Kulkarni and Joshi 2005) [24]. In addition to impeller speed and wind current rate, investigations have considered the influence of electrolyte arrangements (with NaCl and other salt particles) and frothers (compound added substances) on seawater (O'Connor et al. 1990).[25]. The results revealed that a low impeller speed (4.2 m/s) or a high gas speed (0.5 cm/s) produced an air pocket of ocean salt arrangement that was 850 m in size, which was larger than the sizes created by the frother arrangement (600–700 m). Basically.

and Bubbles created in ocean salt arrangement and 0.5 M NaCl were moderately more modest than in deionized water without the frother (Sovechles et al. 2016)[26], which showed that without the frother, bubbles created in ocean salt arrangement and 0.5 M NaCl were moderately more modest than in deionized water. In terms of the fixation range of frothers, the study found that adding a small amount of frother (10 ppm) to the NaCl arrangement (0.5 M) resulted in slightly larger size rises, whereas electrolyte arrangements over the same grouping of 10 ppm resulted in rises of comparable A small resonator was used to determine the general mass thickness of MNB to the dissolvable in 2014 (Kobayashi et al. 2014)[27]. In 2015, researchers used a combination of fluorescence microscopy and other imaging techniques to demonstrate the vaporous surface of NBs. Optical microscopy was used to complete the creation of MNB pictures in 2016 (Azevedo et al. 2016)[28]. NBs were used to help with contaminant evacuation in 2017 and a following report created NBs by a radial syphon (Oliveira et al. 2017). The acceptance time on bubbles-particles was reduced by the foam buoyancy technique NBs in 2019 (Tao and Sobhy 2019)[29]. Furthermore, focuses on scenarios that have been considered before, such as the ionic strength of the electrolyte arrangement in relation to the basic mixture fixation. In comparison to the NaCl arrangement, the ocean salt arrangement (0.7 ionic strength) produced larger air pockets (0.5 ionic strength). Because of the collaboration of salt particles in the ocean salt arrangement, the size of the air pockets grew in the correlation of NaCl arrangement and ocean salt arrangement. Many studies used NaCl as a base with other salt particles (KCl, etc.) to analyse their effect on the size of the air pockets separately, revealing that the other salt particles had no significant effect on the size of the airpockets.

2.5 AN EARLIER OVERVIEW STUDY ON MICRO NANOBUBBLES

In the field of MNBs, there have been substantial advancements and important tests. Epstein Plesset's hypothesis (length of a solitary air pocket in view of its sweep and immersion) was first proposed in 1950 (Plesset and Sadhal 1982)[30]. Natural movies were advised in 1954 to settle small units of gas (one metre), filling in the core.

During cavitation, microbubbles form (Zatakis 1954) [31]. Long-range powers between water-based surfaces were estimated in 1994. Lou et al. 2000[32] used nuclear power microscopy (AFM) to record surface NBs in the year 2000. MNBs were identified as an ultrasonic differentiation specialty in 2003. Surfactants and salt had no effect on the size and state of surface NBs in 2006, according to research. MNBs were evaluated for use in foam buoyancy in 2008 (Fan and Tao 2008)[33]. Cryo-SEM was used to screen MNBs in 2010. and Below Fig 2.2 shows the Flow Chart Of NanoBubble.

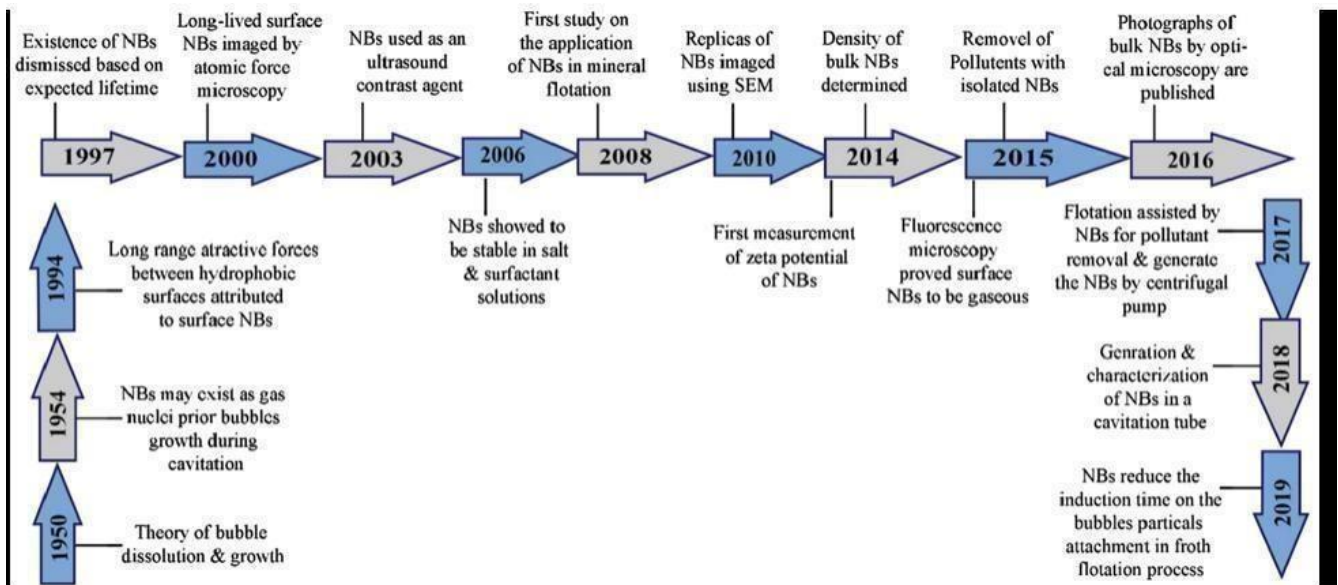


Fig 2.2 Flow Chart of Nano Bubble

2.6 MICRO NANO BUBBLES APPLICATION IN WATERTREATMENT

The Micro nano bubbles have been found to be useful in treatment of water, air movement (Tasaki et al. 2009; Yamasaki et al. 2010)[34], sterilising, and buoyancy methods, according to the research. According to studies, the most critical places of micro nano bubble applications in water treatment include reducing the size of framework, working time, and operational expenses of handling plants, as well as increasing the effectiveness in removing waterpoisons.

2.7 AERATIONPROCESS

The most prevalent method of introducing or penetrating oxygen into a water substance is through air circulation. Air circulation is important in the inventory of oxygen in water treatment since it is a critical component for biochemical platform reactions and sea-going life. Various studies on the impact of air circulation procedures on wastewater and organic water treatment, as well as groundwater recovery, have been conducted. One of the most important objectives of numerous studies was to increase the productivity of the factors that influence mass exchange speed. Disintegrated oxygen, like high-impact frameworks, is an important component of dealing with such deficiencies (Tang et al. 2016)[35]. Because a major amount of the contact gear in such systems uses oxygen, the mass transmission measure of oxygen is criticals that require enormous support costs and electrical information (El-Zahaby and El-Gendy 2016)[36]. As a result, studies have focused on improving standard air pockets and developing an aerator plan to improve mass interchange air circulation. Despite this, research into the use of high mass exchange air pockets isn't well developed on a modern scale. (Weber and Agblevor 2005)[37] studied the characteristics of the gas-fluid mass exchange rate employing Micro nano bubble for air flow in blended tank reactors, concluding that MB air circulation is perfectly adapted to bioreactors. TheyalsofocusedontheeffectofMBaircirculationontheageingofTrichodermareesei(a filamentous parasitethatismesophilic),whichisdependentonaslowrateofoxygengmass-transmission.Becauseof the usage of MB air circulation, the converging of disassembled oxygen was greater than that of the concentration at a lesser discharge rate in this investigation. Furthermore, as during fast development stage, the centralization of cell mass increased rapidly, increasing from 0.1 to 0.18 g/LH compared to standardpercolation.

According to Liu et al. (2015), the germination of the seed was studied using in circulated air through water in contrasting and ordinary water. Similarly, (Park and Kurata 2009)[38] studied the development of lettuce using MB air circulation and found that the dry and new majority of properly circulated air through MB lettuce was 1.7 and 2.1 times higher than with micro bubble air circulation. The authors hypothesized that higher germination and development rates were linked to MNBs' high surface area and their more notable interest in these studies.

positive particles' ability Furthermore, when compared to air micro NBs, oxygen have numerous times higher mass transfer efficacy and numerous times more disintegrating oxygen (DO). Increased mass transfer in the air pocket interface boosts oxygen transmission productivity and causes MBs to linger longer in the water. use for the manipulation of elevated wastes in wastewater treatment with the use of MNBs. The results showed that the rate of oxygen purpose and volume move rate in manufactured circulating air through NB treatment facilities was two times higher than with conventional air bubbles. Natural waste production in NB-circulated air via units did not have a good season. half contrasted and the regular frameworks. In conclusion, the rot and development rate in the NB circulated air through unit was additionally a lot quicker than the customary framework (Temesgen 2017)[39]. Because of such properties, there is further requirement for trial concentrates aroundhere.

2.8 FLOATATIONPROCESS

In the field of water treatment, flotation has also been an important separating procedure (Hopper & McCowen 1952)[40]. Dust, chemicals, organic debris, metal ions, and oils are the most particular contaminants which need to be eliminated from floating (Rubio et al. 2002)[41]. For example, the possibility of boosting flotation efficiency by primarily modifying the features of a bubbling, i.e., interface, the particles qualities has been addressed. NBs and MBs are often employed in flotation to remove contaminants from water more efficiently. Due to the high dissolved gas concentration in the water, repulsion forces at the electrically charged liquid–gas interface inhibit bubble coalescence and therefore improve NB stability, and the tiny concentration gradient between the interface and bulk liquid is maintained. Since NBs have had an impermeable and kinetically stable surface that makes them more resistant to diffusion revealed that NB stability is mostly dependent on hydrogen bonding at the water–gas interface. High gas flow rates with larger bubbles, on the other hand (Miettinen et al.2010)[42].

In Yoon also stated that reducing overall size of the bubbles in flotation is significantly linked to an increase in the likelihood of tiny particles hitting only with tiny bubbles, leading to an increase in separationefficiency.

Surface charges, as well as bubble diameters and small bubbles, play a significant role in flotation (Collins & Jameson 1976; Bui et al. 2015)[43]. Ionized MBs are projected to successfully isolate algae from water, with a cell eradication rate of 90% and a chlorophyll reduction of 92%. The MBs could eliminate more than 30% of organic compounds, such as dissolved and organic carbon, as well as aliphatic or aromatic combinations (Takahashi et al. 2007; Bui et al. 2015)[44].

Also discovered that NBs raised the hydrophilic nature of surface particles and increased the space of flotation particles, resulting in improved flotation efficiency (Sumikura et al. 2007)[45]. Tsai et al. 2007[46] discovered found NB flotation (negatively charged) is a cost-effective method for the mechanical or chemical treatment of wastewater. In MNB trials, the effectiveness of wastewater treatment increased by 40%, with solid trash and silica removed at a rate of 95%. Aside from that, the expense and efficiency of NB-based flotation technique are much cheaper than those of conventional procedures.

2.9 DISINFECTION PROCESS

The use of ozone for oxidation and microbial sanitization is a potential method for wastewater treatment. Concentrates on indicate that ozone gas air pockets successfully cleanse water even with short contact time and poor focus due to their significant sanitization ability. The effectiveness of this method has been expanded as much as possible for synthetic safe spore-forming bacteria (e.g., *Cryptosporidium parvum* and *Bacillus subtilis*). Furthermore, MBs makes this process better effective, as dynamically aseptic technique displays a faster drop rate of *Escherichia coli* (microbes type) (near to 100% decrease) with a smaller water tank and less ozone (for applying MBs) than traditional ozone sterilization. Another test to see if the increase in E can be stopped. With 490 W/L energy, *E. coli* reduced the amount of bacteria by 75% in roughly three minutes. Essentially, the productivity of a non-reagent technology like MNBs for wastewater proper cleaning was proved by hydrodynamic cavitation findings from different tests.

Concentrates further revealed that MBs kill *Bacillus subtilis* and cause larger log reductions (e.g., a 5 log reduction by 140 mg/L, a 1.6 log reduction by 110 mg/L, and a 0.3 log reduction by 40 mg/L in two minutes).

Bacterial deactivation revealed that the burst force of small air pockets determined the success of water sanitization, with a high rate of microorganism decay observed during pool sanitization. Two revolution constructions connected the supply with the bath in this test, The study discovered that a higher NB eruption resulted in better sanitization when compared to other methods such as using an ultrasonic vibrator.

Furthermore, the high-level oxidation process (AOP) has the potential to convert most natural mixtures to CO₂, which is performed either through the direct response of atomic O₃ or through the halfhearted reaction of oxidizing of the hydroxyl revolutionary framed by O₃. Surprisingly, the AOP-based O₃ frameworks, which have been overrun by revolutionaries such as hydroxyl extremists (OH), have demonstrated higher water sanitization productivity. Because of its higher oxidation potential (2.80 V) than direct oxidation, compound oxidation of OH is very susceptible to a wide range of natural poisons in such designs (2.07 V). Regardless, reaction elements should be increased for overall sterilizing effectiveness.

The ozone-based AOP procedure is primarily linked with water properties including alkalinity, type of natural ingredient, pH, and temperature, according to the text. The pH of water, for example, is an important factor in the decomposition of O₃. Despite the fact that MBs increase OH and O₃ levels, which improves sanitization effectiveness, no research has been done on the age of negative effects during sterilisation. Furthermore, further effort is expected in the NB situation. More research is also needed on the impact of MNBs on the efficiency of O₃ usage, as well as reactor improvements and temperature reduction.

2.9.1 Application Of Micro Nano Bubbles In VariousSector

Because of the promising features of MNBs, their use has already been expanded to various industries such as horticulture, healthcare, industry, hydroponics, and homegrown use in recent years. gives an overview of how MNB technology is being used in many The unmistakable properties, for example, higher mass exchange rate, crash productivity, lower rising speed, modified surface charge, and extremist fields.

Because of special attributes, miniature nanobubbles certainly stand out as of late. As of recently, the instruments of MNB age, i.e., the age of air pockets that dislodge air, making bubbles that structure the air, and creating bubbles utilizing electrolysis, have been considered. The utilization of MNB generators in mineral lightness, water treatment, diminishing the opposition of boats, drug organization, and warm stream printing are broadly noticed (Deng et al. 2014). Notwithstanding, there are sure regions where the patterns of MNB application appear to be really encouraging.

For example, because of the improved time-cost effectiveness and lower substance utilization, the use of MNB has incredible potential in ecological manageability notwithstanding water treatment. The unmistakable properties, for example, higher mass exchange rate, crash productivity, lower rising speed, modified surface charge, and extremist age give MNBs a really encouraging job in later procedures of water treatment like sterilization and buoyancy.

In such treatment, high time-cost effectiveness is anticipated with regards to higher natural poison partition, buoyancy, air circulation proficiency for organic medicines, and progressed oxidation utilizing OH revolutionaries. The substance free extreme age property has huge potential in ozone-based MNB utilizes for the oxidation cycle. Further, the higher blasting energy of MNBs and higher air circulation proficiency likewise have ensuing potential as far as diminishing layer fouling and ooze arrangement in film bio-reactors.

Furthermore, future exploration on MNB innovation may likewise zero in on the improvement and mechanization of MNB generators to tweak the MNB age instrument in different areas, including industry and horticulture. For example, further developed brilliant innovations based robotization and control might work with the exact utilization of MNB-based water treatment in horticulture and satisfy the developing interest for water treatment at different scales.

Finally, notwithstanding the immense capability of MNBs as a savvy, productive, and practical treatment innovation, its application is as yet restricted to the lab. Thus future exploration and undertakings need more spotlight on its turn of events and application at the horticultural and modern scales.

MNB is a viable technology that has been used to a broader range of areas during the previous 10 years, including energy, climate, industry, agriculture, and hydroponics. The current state of research and development on MNB utilization in several sectors of water treatment applications, such as buoyancy innovation, sanitization, air circulation, and progressive oxidation, is presented in this audit article. The utilization of MNB innovation in agribusiness and hydroponics, in particular, is quite encouraging, with numerous open possibilities. Despite the fact that the ebb and flow status of examination and practice is always improving, progress is stable. For example, water-related applications in important critical fields like horticulture and hydroponics account for a big amount of the writing available on the MNB application; areas like horticulture and hydroponics; in any case, development is required for areas like clinicalscience.

Further writing shows uncertainty with regards to crucial properties, for example, solidness of mass NBs, which have not been very much made sense of up to this point. A couple of trial concentrates on manage the soundness and life span of NBs, with no impressive agreement. The investigations still can't seem to choose whether properties, for example, detachment and strength keep logical rules (traditional thermodynamic standards). In spite of the fact that headway has been made and a few theories have been proposed making sense of the drawn out dependability of NBs, not a single one of them portray these trial perceptions.

Finally, this study looks for additional examination with respect to enhancements in execution strategies, bubble development, and size under different physical and compound circumstances, bubble age techniques, and robotized advancement.

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There is generally another innovation is expected to treat the water totally or in a fractional manner. The little amount of water treated in research center way which is to be

brought into legitimate framework and clean the water in colossal sum. The expense of this framework is exceptionally low contrast and the other accessible framework portrayal of nanobubbles by ionization strategy for wastewater treatment. a) C. Rameshkumar, b) G. Senthilkumar, c) R. Subalakshmi, d) Risa Gogoid.

There is generally another innovation is expected to treat the water totally or in a fractional manner. The little amount of water treated in research center way which is to be brought into legitimate framework and clean the water in colossal sum. The expense of this framework is exceptionally low contrast and the other accessible framework, and it is extremely simple to deal with.

Contextual investigation on Nanobubbles Technology for Heat Transfer Enhancement to Ethylene Glycol Coolant Oil In this exploration, the hotness move capability of Ethylene Glycol ($C_2H_6O_2$), a coolant for vehicle radiator nanofluids is researched tentatively because of its astounding enemy of freezing qualities. The tried liquid is a combination of water and ethylene glycol with 50:50 extents by volume. Heat exchangers assume a significant part in the field of energy preservation, transformation and recuperation. Uses of ozone miniature and nanobubble advances in water and wastewater treatment. a) J. Korean Soc. This survey gives the outline of utilization of miniature and nano bubble ozonation for cleansing of water and wastewater. The downsides of recently considered procedures and the utilization of the hydrodynamic ozonation to engineered fluid arrangements and different modern wastewaters are deliberately looked into the central peculiarities of nanobubbles and their way of behaving in wastewater treatment advancements. a) Anup Gurung. The significance of nanobubbles is broadly recognized, especially as far as their job regarding bubble size and security. Nanobubbles are minuscule circular cap-formed bubbles and have a few special physical and mechanical qualities Utilization of ozone miniature nano-air pockets to groundwater remediation.

CHAPTER – 3

AIM AND SCOPE OF PRESENT INVESTIGATION

3.1 AIM

The principle point of this undertaking is to utilize miniature nanobubble innovation to lessen Total Dissolved Solids (TDS) of waste clothing water by adding the thankotai powder through Cavitation and Aeration technique And Compare which strategy will decrease more TDS Value. Notwithstanding the different advances that exist in this present reality, like opposite assimilation and refining, for purging of waste clothing water the nanobubble innovation is the cutting edge system for the refinement of waste clothing water and most expense proficient strategy contrast with different techniques. Miniature Nanobubble innovation is an exceptional innovation with a wide scope of uses.

3.2 SCOPE

People waste the water for their desires and utilizations. There are numerous other water treatment processes, for example, refining and opposite assimilation yet this miniature nano bubble innovation has been picked due to its low intricacy and cost viability. This Micronano bubble innovation is an innovation that is arising in this day and age.

KEY BENEFITS FOR MICRO NANO BUBBLE TECHNOLOGY IN WATER

- Reduced chemical usage
- Low Energy usage
- Reduce COD and BOD
- Can use Ozone or any gas
- Low cost of ownership
- High return on investment
- Low maintenance
- Easily service

CHAPTER – 4

MATERIALS ANDMETHODS

4.1 MATERIALS ANDMETHODS

The material we need to perform this method is at first we need Micro Nano Bubble Generator , Laundry Waste Water collected through washing of clothes from washing Machine, Thethankotai Powder, Water Cans and Atmosphere air are used for this process and Materials shown in the Fig 4.1, Fig 4.2, Fig 4.3



Fig 4.1 Washing Machine



Fig 4.2 Thethankotai Powder



Fig 4.3 Cans

4.2 LAUNDRY WASTE WATER SAMPLE CONTAIN THETHANKOTAI POWDER(BEFORE PURIFICATION).

The Laundry waste Water with Thethankotai Powder is contaminated based on the preceding test results. The main goal is to use Micro nano bubble technology to purify this Waste Laundry Water with Thethankotai Powder to reduce TDS . As a result, the first and most important step is to create micro nanobubbles. The technique of hydrodynamic oxidation is used to create micro nano bubbles. The nanobubble generation equipment shown in Fig 4.4. A inlet valves, outlet valves, a nossil shown in Fig 4.5 and a motor shown in Fig4.6 these are the equipment's used for MNBgeneration.

To provide a controlled flow of air, the amount of air to be drawn from the Atmospheric air is adjusted using an inlet valve. So that nanobubbles can be generated in a controlled manner in the water. Bulk nanobubbles, micro-nanobubbles, and macro-nanobubbles are among the nanobubbles produced. It shows the inlet valves in which the pressure is regulated and themotor.



Fig 4.4 Nanobubble Generation Equipment



Fig 4.5 Inlet Valves



Fig 4.6 Motor

Collected wastewater in cans is filled in a nano bubble generator process has been done in the Micro nano bubble generator device.

At First we have washed the garments and gathered that water and filled in the jars through the assistance of line and gathered almost 100 liters in those jars. Then we have added the Thethankotai Powder in those jars for each 35 liters 50 grams of Thethankotai powder is added into that almost we added 150 grams of Thethankotai Powder into those clothing water. We have saved that to the side for 24 hours with practically no development to the water. After that we have gathered 1 litre of test before the interaction and afterward we have emptied the water into Micro Nano Bubble Generator and begin the cycle by turning over the engine the nano bubble generator structures miniature nano bubbles we have proceed with the interaction for 1 hour later that we have gathered something very similar and the generator worked without air and again with air for 1 hour the interaction is proceeds with later that we have gathered those example additionally and we have sent It to the lab to figure out the Values. Fig 4.7 shows the Micro nano bubble generator contains laundry waste water with thethankotai powder and Fig 4.8 shows the floating of dust particles



Fig 4.7 Micro Nano Bubble Generator Contains Laundry Water With Thethankotai Powder



Fig 4.8 Floating of dust particles above the water

CHAPTER - 5

RESULTS AND DISCUSSION

5.1 RESULTS

Table 5.1 Direct Laundry Fresh Water

The Direct Laundry Fresh Water is collected after washing of clothes in the washing Machine and before mixing of Thethankotai Powder in Laundry Waste Water and the TDS Value obtained from the sample given to the lab is 5225 .

Sl No.	Test Parameter	Unit	Test Method	Result
1	TDS	mg/L	IS:3025(Part-16):1984(Reaffirmed 2017)	5225

Table 5.2 Laundry Water Containing Thethankotai Powder

Thethonkotai powder which is mixed in laundry waste water and kept for side Without any movement for one day to reduce water salt level and other impurities. The salt is obtained during washing of clothes which is present in the clothes and the TDS value is 3058

Sl.No	Test Parameter	Unit	Test Method	Results
1	TDS	mg/L	IS:3025(Part-16):1984(Reaffirmed 2017)	3058

Table 5.3 Cavitation 1 hour

The Laundry Waste Water with Thethankotai Powder has poured in Micro Nano Bubble Generator and started the process by switching on the motor which helps To create micro bubbles which separates the dust particles and water. This process is Done without air and the TDS value is 1808.

Sl.No.	Test Parameter	Unit	Test Method	Results
1	TDS	mg/L	IS:3025(Part-16):1984(Reaffirmed 2017)	1808

Table 5.4 Aeration 1 hour

The Laundry Waste Water with Thethankotai Powder has poured in Micro Nano Bubble Generator and started the process by switching on the motor which helps To create micro bubbles which separates the dust particles and water. This process is Done with air and the TDS value is 1562

Sl.No.	Test Parameter	Unit	Test Method	Results
1	TDS	mg/L	IS:3025(Part-16):1984(Reaffirmed 2017)	1562

Table 5.5 Tap Water TDS

This Normal Tap water or Municipality water which we used in our daily life for various purpose and this water is used for washing clothes before mixing od detergent the water is collected to find the TDS value is 1095

Si.No	Test Parameter	Unit	Test Method	Results
1	TDS	mg/L	IS:3025(Part-16):1984(Reaffirmed 2017)	1095

Table 5.6 Comparing TDS Results

From above process the obtained TDS value are compared and show in the Table 5.6

Process	TDS mg/l
Fresh Laundry Water	5225
Laundry Water Contains Thethankotai Powder	3058
Cavitation	1808
Aeration	1562
Tap Water	1095

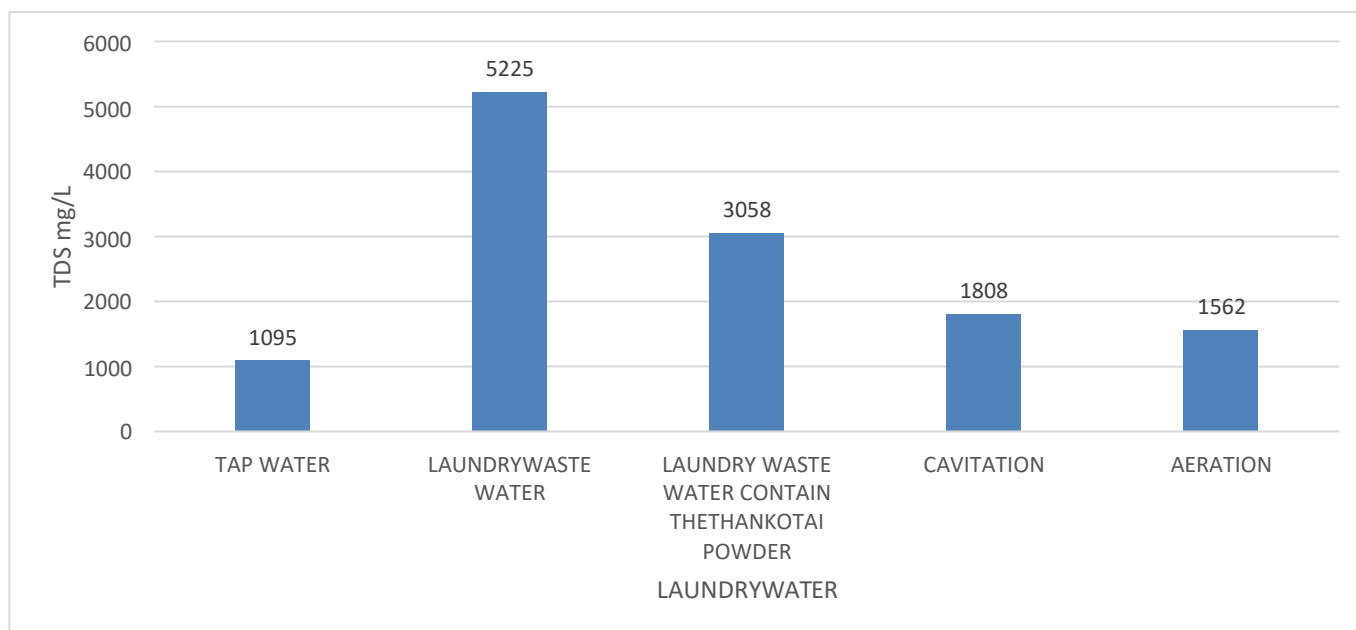


Fig 5.1 shows reduce of TDS value

In the above graph TDS is reducing from fresh laundry water to laundry water with thethankotai powder, cavitation and Aeration for 1 hour. After 1 hour the TDS value is more reduced in aeration than compared to cavitation those reduced TDS values can be seen in the Fig 5.1. After the completion of washing clothes the laundry water has been collected and the TDS value is 5225. After mixing of thethankotai powder in laundry waste water and kept aside for a day without any movement and the sample collected TDS obtained is 3058 nearly 42% tds has reduced by this process. Next pouring the Thethankotai powder laundry water into micro nano bubble generator for cavitation process for 1 hour and the tds value is 1808 around 40% tds reduced compared from above process and again the same process is continues through Aeration and the tds reduces 15% compared through cavitation process tds value is 1562. The normal water tds is 1095 which is normal water without mixing any detergent which we used in our daily life for different aspects. From above Fig 5.1 shows the decrease of TDS of Laundry waste water from 5225 to 1562.

EXPLANATION

From the above cases the laundry waste water is treated through Micro Nano bubble Generator device which is added with Thethankotai powder, With Air and Without Air after these samples are taken for 1 hour respectively. Each sample is tested in Falcon L

Chennai. Due to decreases in the TDS in each sample then the impurities and salt content in the laundry waste water reduced. So we can reduce the TDS values by the help of Micro Nano Bubble Technology. Comparing to cavitation process the Aeration process gives the better result and later the water can reuse for toilet and plantings.

5.2 DISCUSSION

Subsequent to examining the qualities of Micro Nanobubbles and deciding the air pocket number thickness, bubble measurement. we are currently continuing on to the following stage, which is deciding the degree to which water might be decontaminated using nanobubble innovation. The water gathered after the nanobubbles are made is conveyed to a research center. Aggregate sum of broken down solids (TDS), complete suspended solids (TSS), measure of phosphate content, measure of chromium content, measure of sulfides present in the example, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), The experimental outcomes are currently accessible following seven days the tests results are displayed in the above tables from table 5.1 to 5.5.

CHAPTER 6

SUMMARY AND CONCLUSION

6.1 SUMMARY

Nanotechnology is a term used to address parts of science and designing that exploit nanoscale peculiarities in the plan, portrayal, manufacture, and utilization of materials, constructions, gadgets, and frameworks. Water treatment methods are progressively fusing nanotechnology. Nanotechnology is the method involved with controlling molecules on a nanoscale. In nanotechnology, nano films are utilized to relax water while likewise taking out contaminations like physical, organic, and synthetic pollutants. It is feasible to make nanobubbles . From that point forward, the nanobubbles will be utilized to remediate ground water. From that point forward, the water is shipped for testing to decide its quality. The outcomes are then used to lead some examination.

6.2 CONCLUSION

To diminish Landry Water TDS by the course of Cavitation and Aeration through Micro nanobubble innovation with 100 liters of clothing water with various time frame, such as running machine for 1 hour right off the bat for cavitation and air circulation, tests are given for testing. Also, Later the consequences of the examples are given by the lab there we see that by contrasting all TDS worth of the relative multitude of cycles the Value of TDS is decreased more in Cavitation process. Cavitation Process by looking at cycle of Aeration. After that we have run the machine for 1 hour for Aeration interaction to lessen more TDS esteem And for reference we appended the outcomes in the above pages.

At long last, we Conclude that by Comparing Cavitation and Aeration processes the TDS worth of Laundry Water is most decreased in Aeration Process.

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REFERENCES :

1. Jia W. H. Ren S. L. Hu B. 2013 Effect of water chemistry on zeta potential of air bubbles. *International Journal of Electrochemical Science* 8 (4),5828–5837.
2. Jia W. H. Ren S. L. Hu B. 2013 Effect of water chemistry on zeta potential of air bubbles. *International Journal of Electrochemical Science* 8 (4),5828–5837.
3. Ohgaki K. Khanh N. Q. Joden Y. Tsuji A. Nakagawa T. 2010 Physicochemical approach to nanobubble solutions. *Chemical Engineering Science* 65(3),1296–1300.
4. Wang S. Liu M. Dong Y. 2013 Understanding the stability of surface nanobubbles. *Journal of Physics: Condensed Matter* 25 (18),184007.
5. Wilkinson P. M. van Dierendonck L. L. 1990 Pressure and gas density effects on bubble break-up and gas hold-up in bubble columns. *Chemical Engineering Science* 45 (8),2309–2315.
6. Bouaifi M. Hebrard G. Bastoul D. Roustan M. 2001 A comparative study of gas hold-up, bubble size, interfacial area and mass transfer coefficients in stirred gas–liquid reactors and bubble columns. *Chemical Engineering & Processing: Process Intensification* 40 (2),97–111.
7. Whitman W. G. 1962 The two film theory of gas absorption. *International Journal of Heat and Mass Transfer* 5 (5),429–433.
8. Terasaka K. Hirabayashi A. Nishino T. Fujioka S. Kobayashi D. 2011 Development of microbubble aerator for waste water treatment using aerobic activated sludge. *Chemical Engineering Science* 66 (14),3172–3179.
9. Bredwell M. D. Worden R. M. 1998 Mass-transfer properties of microbubbles. 1. Experimental studies. *Biotechnology Progress* 14 (1),31–38.
10. Ying K. Al-Mashhadani M. K. H. Hanotu J. O. Gilmour D. J. Zimmerman W. B. 2013 Enhanced mass transfer in microbubble driven airlift bioreactor for microalgal culture. *Engineering* 5 (9),735–743.
11. Li X. Li P. Zu L. Yang C. 2016 Gas–liquid mass transfer characteristics with microbubble aeration – I. Standard stirred tank. *Chemical Engineering & Technology* 39 (5),945–952.
12. Wu C. Nasset K. Masliyah J. Xu Z. 2012 Generation and characterization of submicron size bubbles. *Advances in Colloid & Interface Science* 179–182,123–132.
13. Kim J.-H. von Gunten U. Mariñas B. J. 2004 Simultaneous prediction of *Cryptosporidium parvum* oocyst inactivation and bromate formation during ozonation

of synthetic waters. *Environmental Science & Technology* 38 (7), 2232–2241.

14. Agarwal A. Ng W. J. Liu Y. 2011 Principle and applications of microbubble and nanobubble technology for water treatment. *Chemosphere* 84 (9), 1175–1180.

Ahmadi R. Darban A. K. 2013 Modeling and optimization of nano-bubble generation process using response surface methodology. *International Journal of Nanoscience and Nanotechnology* 9 (3), 151–162.

15. Parmar R. Majumder S. K. 2013 Microbubble generation and microbubble-aided transport process intensification – a state-of-the-art report. *Chemical Engineering & Processing: Process Intensification* 64, 79–97.

16. Fan M. M. Tao D. Honaker R. Luo Z. F. 2010a Nanobubble generation and its application in froth flotation (part I): nanobubble generation and its effects on properties of microbubble and millimeter scale bubble solutions. *Mining Science and Technology (China)* 20 (1), 1–19.

17. Parmar R. Majumder S. K. 2013 Microbubble generation and microbubble-aided transport process intensification – a state-of-the-art report. *Chemical Engineering & Processing: Process Intensification* 64, 79–97.

18. Fan M. M. Tao D. Honaker R. Luo Z. F. 2010a Nanobubble generation and its application in froth flotation (part I): nanobubble generation and its effects on properties of microbubble and millimeter scale bubble solutions. *Mining Science and Technology (China)* 20 (1), 1–19.

19. Ahmadi R. Darban A. K. 2013 Modeling and optimization of nano-bubble generation process using response surface methodology. *International Journal of Nanoscience and Nanotechnology* 9 (3), 151–162.

20. Wu C. Nasset K. Masliyah J. Xu Z. 2012 Generation and characterization of submicron size bubbles. *Advances in Colloid & Interface Science* 179–182, 123–132.

21. Cho S. H. Kim J. Y. Chun J. H. Kim J. D. 2005 Ultrasonic formation of nanobubbles and their zeta-potentials in aqueous electrolyte and surfactant solutions. *Colloids & Surfaces A* 269 (1–3), 28–34.

22. de Rijk S. E. van der Graaf J. H. J. M. den Blanken J. G. 1994 Bubble size in flotation thickening. *Water Research* 28 (2), 465–473.

23. Ushikubo F. Y. Furukawa T. Nakagawa R. Enari M. Makino Y. Kawagoe Y. Shiina T. Oshita S. 2010 Evidence of the existence and the stability of nano-bubbles in water. *Colloids and Surfaces A: Physicochemical and Engineering Aspects* 361 (1–3), 31–37.

24. Kulkarni A. A. Joshi J. B. 2005 Bubble formation and bubble rise velocity in gas – liquid systems: a review. *Industrial & Engineering Chemistry Research* 44(16), 5873–

5931.

25. O'Connor C. T. Randall E. W. Goodall C. M. 1990 Measurement of the effects of physical and chemical variables on bubble size. *International Journal of Mineral Processing* 28 (1–2),139–149.

26. Sovechles J. M. Lepage M. R. Johnson B. Waters K. E. 2016 Effect of gas rate and impeller speed on bubble size in frother–electrolyte solutions. *Minerals Engineering* 99,133–141.

27. Kobayashi H. Maeda S. Kashiwa M. Fujita T. 2014 Measurements of ultrafine bubbles using different types of particle size measuring instruments. In: *International Conference on Optical Particle Characterization (OPC 2014)*. (N. Aya, N. Iki, T. Shimura & T. Shirai, eds), SPIE, Bellingham, WA, USA,92320U.

28. Azevedo A. Etchepare R. Calgarato S. Rubio J. 2016 Aqueous dispersions of nanobubbles:generation,propertiesandfeatures.*MineralsEngineering*94,29–37.

29. TaoD.SobhyA.2019Nanobubbleeffectsonhydrodynamicinteractionsbetween particles and bubbles. *Powder Technology* 346,385–395.

30. Plesset M. S. Sadhal S. S. 1982 On the stability of gas bubbles in liquid–gas solutions. *Applied Scientific Research* 38 (1),133–141.

31. Zataakis H. 1954 Sound field of a moving cylinder and a moving sphere. *Journal of the Acoustical Society of America* 26 (2),169–173.

32. Lou S. T. Ouyang Z. Q. Zhang Y. Li X. J. Hu J. Li M. Q. Yang F. J. 2000 Nanobubbles on solids surface imaged by atomic force microscopy. *Journal of Vacuum Science & Technology B* 18 (5),2573–2575.

33. Fan M. M. Tao D. 2008 A study on picobubble enhanced coarse phosphate froth flotation. *Separation Science and Technology* 43 (1),1–10.

34. Tasaki T. Wada T. Fujimoto K. Kai S. Ohe K. Oshima T. Baba Y. Kukizaki M. 2009 Degradation of methyl orange using short-wavelength UV irradiation with oxygen microbubbles. *Journal of Hazardous Materials* 162 (2–3),1103–1110.

Yamasaki K. Sakata K. Chuhjoh K. 2010 Water Treatment Method and Water Treatment System. US7662288B2, Google Patents.

35. Tang C.-C. Zuo W. Tian Y. Sun N. Wang Z.-W. Zhang J. 2016 Effect of aeration rate on performance and stability of algal–bacterial symbiosis system to treat domestic wastewater in sequencing batch reactors. *Bioresource Technology* 222,156–164.

36. El-Zahaby A. M. El-Gendy A. S. 2016 Passive aeration of wastewater treated by an anaerobic process – a design approach. *Journal of Environmental Chemical Engineering* 4 (4),4565–4573.

37. Weber J. Agblevor F. A. 2005 Microbubble fermentation of *Trichoderma reesei* for cellulase production. *Process Biochemistry* 40 (2), 669–676.
38. Park J.-S. Kurata K. 2009 Application of microbubbles to hydroponics solution promotes lettuce growth. *HortTechnology* 19 (1), 212–215.
39. Temesgen T. 2017 Enhancing Gas–Liquid Mass Transfer and (Bio) Chemical Reactivity Using Ultrafine/Nanobubble in Water and Wastewater Treatments. Doctoral thesis, Graduate School of Seoul National University, Seoul, South Korea.
40. Hopper S. H. McCowen M. C. 1952 A flotation process for water purification. *Journal – American Water Works Association* 44 (8), 719–726.
41. Rubio J. Souza M. L. Smith R. W. 2002 Overview of flotation as a wastewater treatment technique. *Minerals Engineering* 15 (3), 139–155.
42. Miettinen T. Ralston J. Fornasiero D. 2010 The limits of fine particle flotation. *Minerals Engineering* 23 (5), 420–437.
43. Collins G. L. Jameson G. J. 1976 Experiments on the flotation of fine particles: the influence of particle size and charge. *Chemical Engineering Science* 31 (11), 985–991.
44. Takahashi M. Chiba K. Li P. 2007 Free-radical generation from collapsing microbubbles in the absence of a dynamic stimulus. *The Journal of Physical Chemistry B* 111 (6), 1343–1347.
45. Sumikura M. Hidaka M. Murakami H. Nobutomo Y. Murakami T. 2007 Ozone micro-bubble disinfection method for wastewater reuse system. *Water Science & Technology* 56 (5), 53–61.

APPENDIX

Tap Water TDS

ISO / IEC 17025
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FALCON
Building Materials & Soil Testing
FALCON INDUSTRIAL TESTING
LABORATORY PVT LTD.

TEST REPORT

Test Report No: TR2204044-01	Date: 05.03.2022	Page 1 of 1
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CUSTOMER DETAILS

Customer Name & Address : *Dr. Purusothaman, Dr. Senthil Kumar,
Mr. Krishna Sagar, Mr. Y. Pavankumar*

Customer Reference : Test Request Form dated on 05.03.2022

Identification by Customer : Direct Laundry Fresh Water

SAMPLE DETAILS

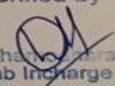
Sample Code : 2204110-01	Sampled on : 05.03.2022
Sample Name : WATER	Sampled by : Customer
Sample Description : TAP WATER	Sample Received Qty : 2 Lit
Marked in Sample : ---	Sampling Procedure : ---
Test Started on : 05.03.2022	Sample Received on : 05.03.2022
Test Completed on : 05.03.2022	Sample Condition : Fit for analysis

Sl. No.	Test Parameter	Unit	Test Method	Results
1	Total Dissolved Solids	mg/L	IS:3025 (Part-16):1984 (Reaffirmed 2017)	1095



*** End of Test Report ***

Verified by



J. Dharmarajan
Lab Incharge

FALCON INDUSTRIAL TESTING LABORATORY PVT. LTD.,
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Chennai - 600 096. Tamilnadu, India.

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+ 91 87545 95273 - Soil Test & Technical

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Terms and Conditions :

- Ⓒ The test results relate to the items tested
- Ⓒ The report is generated for the sole use and specific purpose of the customer and based on item/sample submitted by the customer.
- Ⓒ The report shall not be considered to be the representative of similar or equivalent items.
- Ⓒ Any correction makes this report invalid.

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Direct Laundry Fresh Water

ISO / IEC 17025
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Building Materials & Soil Testing
FALCON INDUSTRIAL TESTING
LABORATORY PVT. LTD.

TEST REPORT

Test Report No: TR2203101-01	Date: 02.03.2022	Page 1 of 1
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CUSTOMER DETAILS

Customer Name & Address : *Dr. Purusothaman, Dr. Senthil Kumar,
Mr. Krishna Sagar, Mr. Y. Pavankumar*

Customer Reference : Test Request Form dated on 01.03.2022

Identification by Customer : Direct Laundry Fresh Water

SAMPLE DETAILS

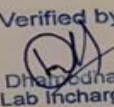
Sample Code : 2203101-01	Sampled on : 01.03.2022
Sample Name : WATER	Sampled by : Customer
Sample Description : Laundry Fresh Water	Sample Received Qty : 2 Lit
Marked in Sample : TJ2203001-01	Sampling Procedure : ---
Test Started on : 02.03.2022	Sample Received on : 01.03.2022
Test Completed on : 02.03.2022	Sample Condition : Fit for analysis

Sl. No.	Test Parameter	Unit	Test Method	Results
1	Total Dissolved Solids	mg/L	IS:3025 (Part-16):1984 (Reaffirmed 2017)	5225

*** End of Test Report ***



Verified by


J. Dharmadharan
 Lab Incharge

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Laundry Water Containing Thethankotai Powder

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NABL ACCREDITED LABORATORY



TEST REPORT

Test Report No: TR2203101-02	Date: 02.03.2022	Page 1 of 1
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CUSTOMER DETAILS

Customer Name & Address	: Dr. Purusothaman, Dr. Senthil Kumar, Mr. Krishna Sagar, Mr. Y. Pavankumar
Customer Reference	: Test Request Form dated on 01.03.2022
Identification by Customer	: Laundry Water containing Thankotai Powder

SAMPLE DETAILS

Sample Code	: 2203101-02	Sampled on	: 01.03.2022
Sample Name	: WATER	Sampled by	: Customer
Sample Description	: Laundry Water	Sample Received Qty	: 2 Lit
Marked in Sample	: TJ2203001-02	Sampling Procedure	: ---
Test Started on	: 02.03.2022	Sample Received on	: 01.03.2022
Test Completed on	: 02.03.2022	Sample Condition	: Fit for analysis

Sl. No.	Test Parameter	Unit	Test Method	Results
1	Total Dissolved Solids after Filtration	mg/L	IS:3025 (Part-16):1984 (Reaffirmed 2017)	3058



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Cavitation 1 hour

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TEST REPORT

Test Report No: TR2203023-01	Date: 05.03.2022	Page 1 of 1
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CUSTOMER DETAILS

Customer Name & Address	: Dr. Purusothaman, Dr. Senthil Kumar, Mr. Krishna Sagar, Mr. Y. Pavankumar
Customer Reference	: Test Request Form dated on 03.03.2022
Identification by Customer	: Purification of Laundry water contains Thethankotai powder using nano bubble technology without air

SAMPLE DETAILS

Sample Code	: 2203105-01	Sampled on	: 03.03.2022
Sample Name	: WATER	Sampled by	: Customer
Sample Description	: Laundry Water	Sample Received Qty	: 2 Lit
Marked in Sample	: Without Air	Sampling Procedure	: ---
Test Started on	: 04.03.2022	Sample Received on	: 03.03.2022
Test Completed on	: 05.03.2022	Sample Condition	: Fit for analysis

Sl. No.	Test Parameter	Unit	Test Method	Results
1	Total Dissolved Solids	mg/L	IS:3025 (Part-16):1984 (Reaffirmed 2017)	1808



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Aeration 1 hour

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TEST REPORT

Test Report No: TR2203023-02

Date: 05.03.2022

Page 1 of 1

CUSTOMER DETAILS

Customer Name & Address : Dr. Purusothaman, Dr. Senthil Kumar,
Mr. Krishna Sagar, Mr. Y. Pavankumar

Customer Reference : Test Request Form dated on 03.03.2022

Identification by Customer : Purification of Laundry water contains Thethankotai powder using nano bubble
technology with air

SAMPLE DETAILS

Sample Code : 2203105-02

Sampled on : 03.03.2022

Sample Name : WATER

Sampled by : Customer

Sample Description : Laundry Water

Sample Received Qty : 2 Lit

Marked in Sample : With Air

Sampling Procedure : ---

Test Started on : 04.03.2022

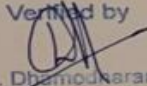
Sample Received on : 03.03.2022

Test Completed on : 05.03.2022

Sample Condition : Fit for analysis

Sl. No.	Test Parameter	Unit	Test Method	Results
1	Total Dissolved Solids	mg/L	IS:3025 (Part-16):1984 (Reaffirmed 2017)	1562

*** End of Test Report ***

Verified by

J. Dharmodharan
Lab Incharge



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