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EXPERIMENTAL INVESTIGATION ON WATER TREATED SLUDGE

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Abstract

To ensure compliance with legal requirements, users must concentrate their sewage/wastewater treatment process. The primary goal of sewage treatment is the removal of numerous hazardous load components from the environment, including solids, organic carbon, nutrients, inorganic salts, and metals, pathogens, and others. Effective wastewater collection and treatment is essential for the environment and for public health. Protecting the environment in a way that is beneficial to public health and socioeconomics is the main goal of seawater management. Wastewater management's ultimate objective is to reduce the amount of water and organic material used in wastewater in an environmentally friendly manner. Sewage and waste water treatment is carried out using a variety of techniques to reduce the amount of water and wastewater containing organic material. Examining issues with public health and socioeconomics is essential.

Key words: Sewage Treatment, Compressive Strength, Conservation, Sewage Water, Mortar.

I. INTRODUCTION

Waste water is a fluid waste that is disposed of by family units, commercial properties, industry, and agriculture. It frequently contains a few toxins due to the mixing of waste water from various sources. Depending on the source, waste water is referred to as sanitary, commercial, manufacturing, agrarian, or surface runoff. It is vital to distinguish between the word's wastewater and wastewater, as the terms wastewater and wastewater are frequently interchanged. Sewage is either tainted with garbage or pee. Sewage is produced by living arrangements, hospitals, offices, and additions, among other things. Sewage is defined as residential, urban, or industrial liquid that is typically arranged by a canal or sewer (sanitary or connected); local sewage contains a wide range of separate and suspended pollution and is one of the most significant sources of pollutants and organic compounds that disintegrate (microorganisms that cause disease). Because viruses are released into waste, all sewage from metropolitan networks and urban organizations will contain pathogens of some form, potentially indicating a current threat to public health. [1]

Key roads for industrial water reuse are drainage, surface water renewal, and groundwater recharge. The amount of water moved along each path is determined by geohydrology, climate, and watershed conditions, as well as the amount of water used and the amount of water reused for various purposes both immediately and backhandedly. The criteria for a water reuse circle should include general health, building, financial aspects, style, and, most importantly, open acceptance. Given the complexities of waste water reuse initiatives, caution must be exercised in implementing the following features.

Historically, the primary source of reclaimed water has been wastewater from wastewater collection facilities. However, a wider range of potential water sources for reclamation and reuse have been taken into consideration due to population growth and urbanization, as well as limited reliable water resources. Additional sources of wastewater that may be recovered and used are listed in Table 3. Decentralized wastewater management systems work best for many of the water sources listed in Table 1.2. For instance, a complete on-site wastewater recycling system for the creation of drinking water was constructed in the late 1970s. These systems were installed in a variety of Colorado (USA) homes between 1976 and 1982 (Tchobanoglous et al., 2011).

India receives the second-highest quantity of precipitation in the world. In our nation, there are many uses for water, with 85% going to agriculture, 10% to industry, and 5% to residential use. According to the World Water Institute, India would be a water-stressed country starting in 2020. The term "water stress" refers to the availability of fewer than 1000 m3 of water per person per year (Proceedings of the Trombay Symposium on Desalination and Water Reuse on the water situation in India, 2007). Our country receives an average of 1200 mm of rainfall per year, with a maximum of 1100 mm in Cherrapunji and a minimum of 250-300 mm in West Rajasthan. [6]

Reusing wastewater has both positive and bad consequences. Job creation, food security for disadvantaged urban and peri-urban farms, and efficient irrigation water and wastewater supplement reuse are all positive outcomes. Due to the consistent availability of waste water, urban vulnerable farmers and migratory professionals may count on work throughout the year. Nearly 43 percent of the utilization of family food units was reported to be irrigated with waste water by paddy along Musi, Hyderabad in the peri-urban zones. The high supplement content of wastewater helps farmers save money on manure and reliably increases the force of crops. Property values may be significantly impacted by wastewater in either a positive or negative way. However, because waste water is only partially treated or not treated at all, it endangers the very positions it produces in the long run. Agricultural waste water can be used in a variety of ways, but in the long run, it raises salinity in the land, accumulates heavy metals in the soil, and eventually leads to the collapse of the earth's structure. As a result, harvesting possibilities are limited, and long-term yields are reduced. Along the Musi River near Hyderabad, where waste water is removed from the stream for irrigation, paddy (rice) yields have dropped by 40-50 percent. There is ample evidence that groundwater in all irrigated waste water fields has elevated salt levels and is not appropriately prepared for usage. High groundwater tables and waterlogging, in addition to other factors, are common in these areas. Various microorganisms, such as protozoa, can be found in waste water and can cause disease.

II. OBJECTIVES

The following are the research's goals:

- Quantification of water treatment sludge settled in the clariflocculator.
- Physicochemical characterization of the sludge generated in clariflocculator.
- Investigation of pozzolanic properties of the water treatment sludge.
- Investigation of physical as well as mechanical properties of mortar prepared with cement-sludge mixture.
- Assessing the feasibility of recycling water treatment sludge for beneficial reuses in construction industry.

III. METHODOLOGY

Design of the Study

Raw water and sludge samples are collected as part of the process. The method for analysing the sludge produced and the procedure for analysing water quality.

Water samples are collected

Water samples were gathered at a 120 MLD (million litres per day) wastewater treatment facility in Pune, India. Water treatment plants receive raw water from the top end. The water is collected in a conduit that leads to the input tank, where PACl is injected as a coagulant, and then into the mixing tank for fast coagulation mixing.

Water samples are analyzed

In Pune, India, sludge samples are taken from the same sludge for water treatment. The clariflocculator unit produces chemical sludge, which is collected and helps with disposal through the sludge drain (Patil P. J & S, 2017). The micro solids that have remained on the filter media are removed by backwashing exhausted filter beds with SFBW, which contains finer, harder particles. The clariflocculator sludge and SFBW are discarded together. Different treatment units produce waste and residues with varying physicochemical characteristics. After being removed from the SFBW, the clariflocculator sludge (CFS) and filter backwash solids (FBS) are brought to the lab for physicochemical analysis.

Sludge Quantification

The amount of alum sludge created can be closely predicted by considering the reactivity of alum in the coagulation process and accounting for the sludge contribution from turbidity. Sludge generation is evaluated in the water treatment facility using technical literature references (Salvi et al., 2021). Cornwell and Roth devised an empirical model for calculating sludge formation in water treatment plants using PACl as a coagulant.

Samples of sludge are being taken

Samples of sludge were taken from the

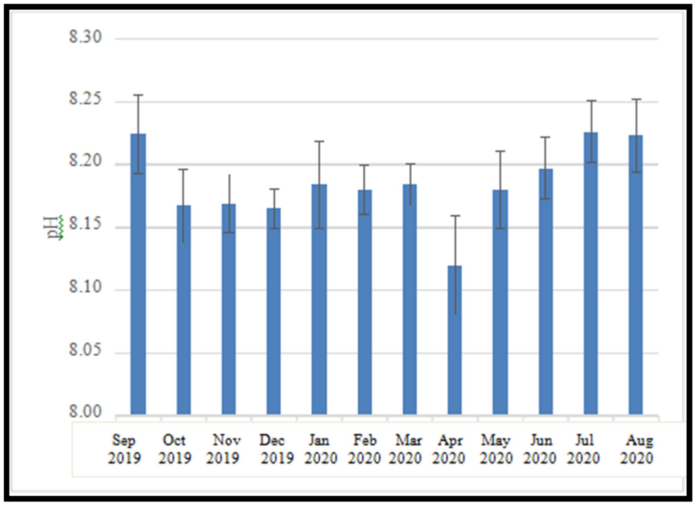
same WTP in Pune, India. The sludge pipe is used to remove and discard the chemical sludge the clariflocculator device produces. SFBW is a smaller version of SFBW. Backwashing of used filter beds with solid particles removes tiny particulates that have adhered to the filter material. Along with the clariflocculator sludge, the SFBW is also removed to be disposed of. The physical qualities of the waste/residues produced by different treatment units differ. As a result, the Clariflocculator sludge (CFS) and filter backwash solids (FBS) discovered in the SFBW are collected separately and sent to the laboratory to be analyzed.

Sludge samples are characterized

The dry CFS and FBS that are brought to the lab are pulverized to the desired particle size for physicochemical analysis (Natarajan et al., 2022). Physical traits like particle size distribution, pH, moisture content, volatile matter, ignition failure, CFS, and FBS were discovered during the WTP examination (Samiksha & Salvi, 2018). Studies are being done on chemical structure, surface morphology, and thermal behaviour. According to Indian standard IS 2720 (Part 4): 1985, the particle size distribution of CFS and FBS is determined using a sieve analysis and hydrometer technique. The pH is determined using the Indian Standard Soil Test Method: pH Value Determination (IS 2720 (Part 26): 1987. The quality of volatile matter and the absence of combustion were measured using CFS and FBS heating in the furnace with a muffle and test techniques for ordinary water and waste water (APHA, 1998). ED-XRF is used to calculate trace elements while WD-XRF is used to analyze the main chemical compounds found in CFS and FBS. The morphology of CFS and FBS is investigated using a scanning electron microscope, or SEM, on a Jeol model JSM 6510 LV. Using a Rigaku X-ray diffractometer, CFS and FBS minerals were screened to obtain an X-ray diffraction (XRD) pattern of 2> spanning 10 to 85 degrees. The International Centre for Diffraction Data Archive has a list of crystalline stages. The SDT Q600 TA method uses thermogravimetric (TG) and differential thermal measurements to determine thermal behaviour (DTA). The samples are heated to a maximum temperature of 1000 ° C at a rate of 10° C per minute under a nitrogen flow (100 mL/minute).

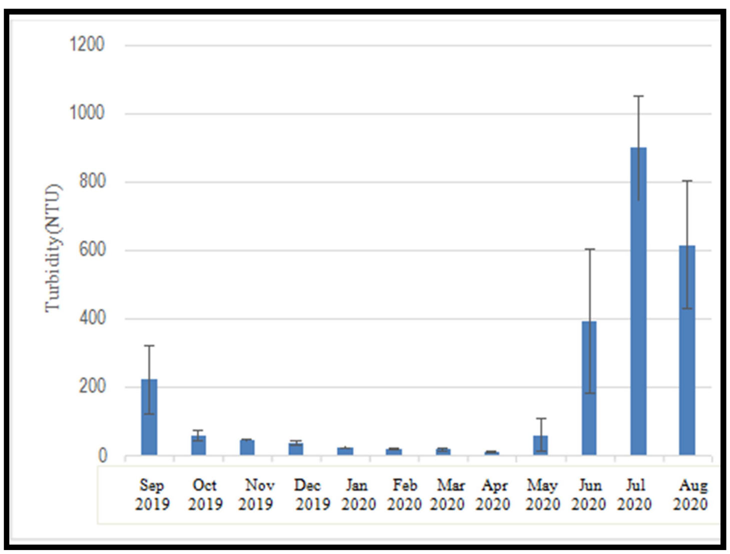
IV. RESULTS

The pH of raw water obtained at the plant is approximately 8.05-8.27 and the lowermost mean monthly pH of 8.12 ± 0.040 is observed for the month of April 2020, while the highest mean monthly pH of 8.23 ± 0.025 is observed for the month of July 2020. As the estimated raw water pH value is about 8, the pH of the incoming raw water fluctuates greatly.



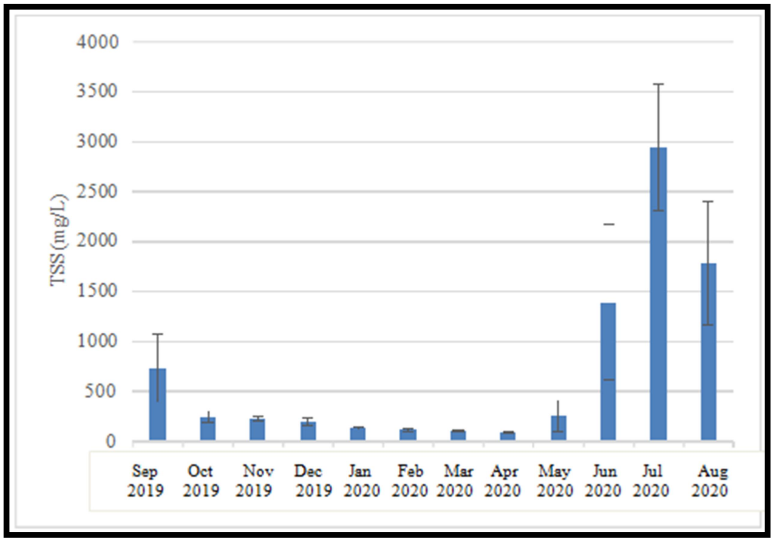
Monthly Variation in the pH of Raw Water

The average turbidity value was found to be the lowest in April 2020, at 12.57 ± 1.10 NTU, whereas the maximum turbidity value was found to be 899.9 ± 154.13 NTU in July 2020. In the month of July 2020 , raw water turbidity always crosses the 1000 NTU level and begins to fall afterwards.



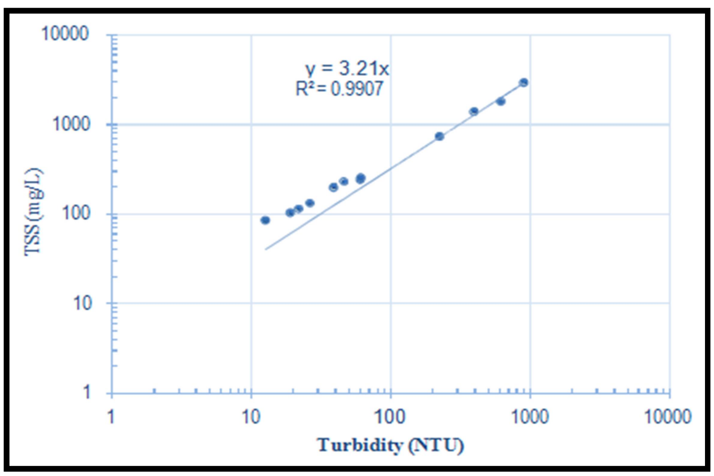
Monthly variation in the turbidity of raw water

The lowermost and uppermost values for the average monthly TSS concentration were found to be 85 and 7 mg/L in April 2020 and 2945 and 634 mg/L in July 2020, respectively. In July 2020, extremely heavy rains brought about by the monsoon caused flooding in the Ganges River and surface runoff in the north-western part of India. The water treatment plant discovered that the turbidity and TSS levels of incoming raw water were extremely high from June to September 2020 during the monsoon season.



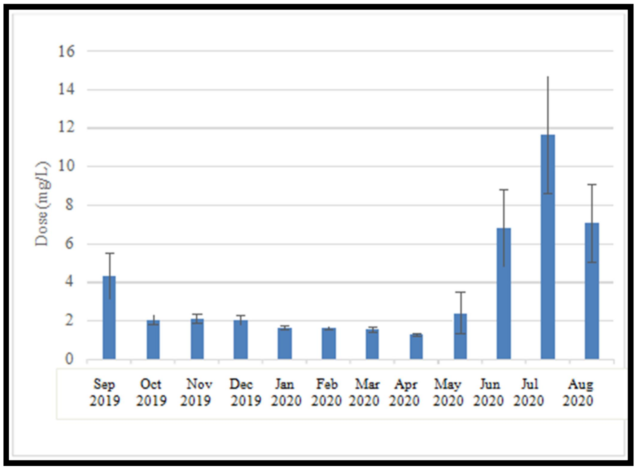
Monthly variation in the TSS of raw water

In the present case, the turbidity coefficient is found to be 3.21, but Cornwell and Roth (2010) noted that the coefficient value vary from 0.7 to 2.2 for the water treatment plant, which mainly decreases turbidity. Due to the existence of isolated particles of differing sizes that contribute further to the TSS level instead of imparting greater turbidity, the turbidity coefficient is observed to be high.



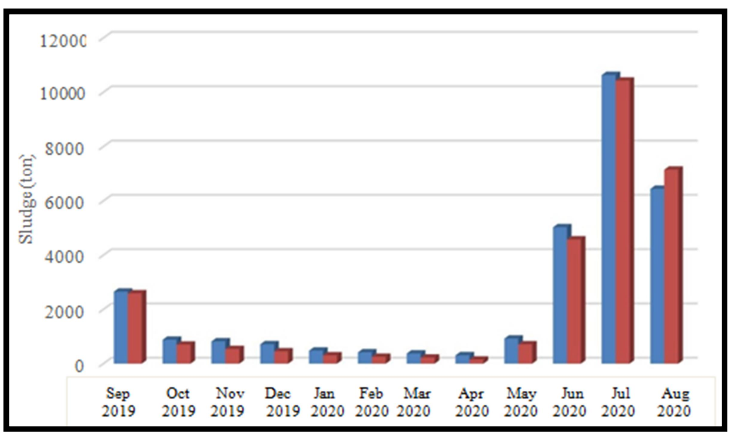
Turbidity v/s TSS correlation

The dosage of PACl is similar to that of turbidity and TSS, but may not differ to the same degree that the higher coagulant dose might not be needed for unstable and separate particles.



Monthly difference in the dosage of coagulant

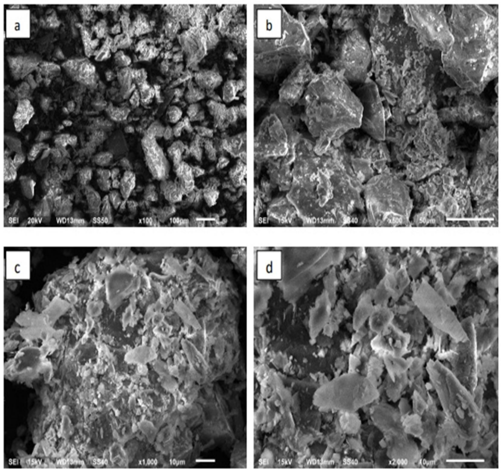
WTS output was discovered to be significant during the monsoon season, with a cumulative amount of 10,635 tonnes in the month of July 2022. Extremely turbid raw water was gathered at the water treatment facility during the months of June 2022 to September 2022 as a result of the production of such a large amount of WTS. Using the TSS value calculated during the monitoring phase, the total annual WTS output is estimated at 29.700 tons. However, the gross sludge is calculated to be 28,100 tons utilizing the TSS v/s turbidity correlation, with a difference of just around 5 percent.



Monthly variation in the WTS production

Sludge Characterization – CFS

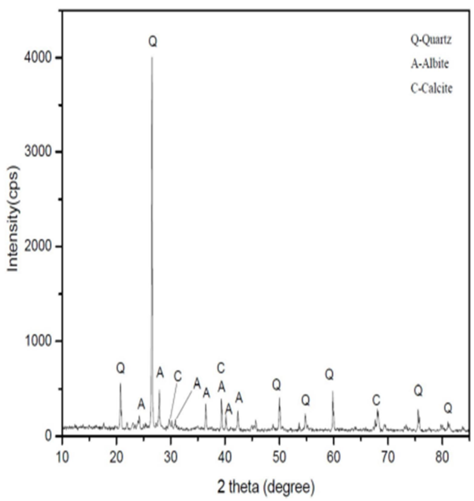
Morphological Characteristics



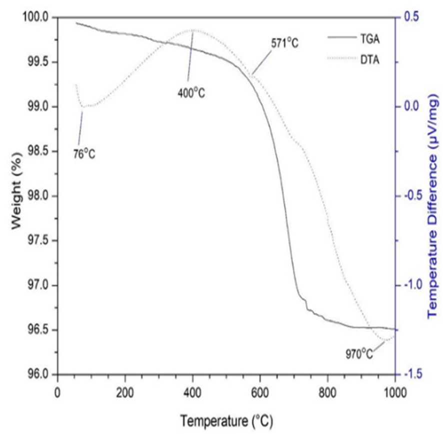
Chemical Composition

Compounds	%W/W	Elements	ppm
SiO_2	52.320	Ba	537.522
Al_2O_3	9.890	Cr	317.738
Fe_2O_3	3.370	Zr	242.927
CaO	3.860	W	164.101
K_2O	2.720	Rb	100.387
MgO	1.850	Sr	80.582
Na_2O	0.940	Cu	27.746
TiO_2	0.490	Y	25.933
P_2O_5	0.170	Ni	22.737
MnO	0.055	Pb	17.286
ZnO	0.100	As	10.339
Carbonaceous matter	24.079	Nb	8.088

Mineralogical Characteristics

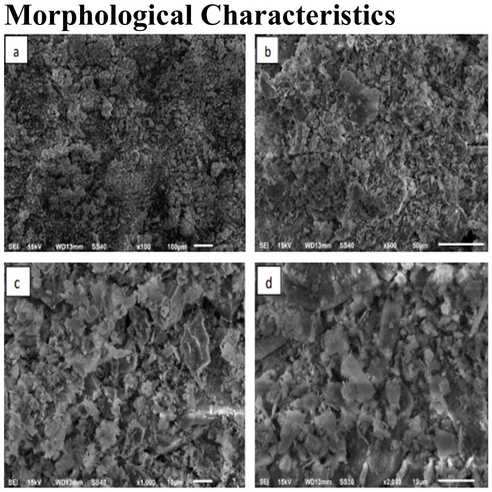


Thermal Composition



Sludge Characterization – FBS

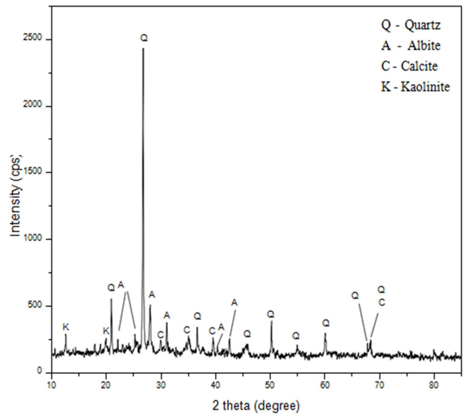
Morphological Characteristics

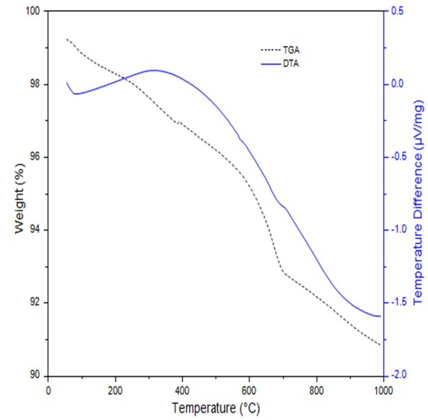


Chemical Composition

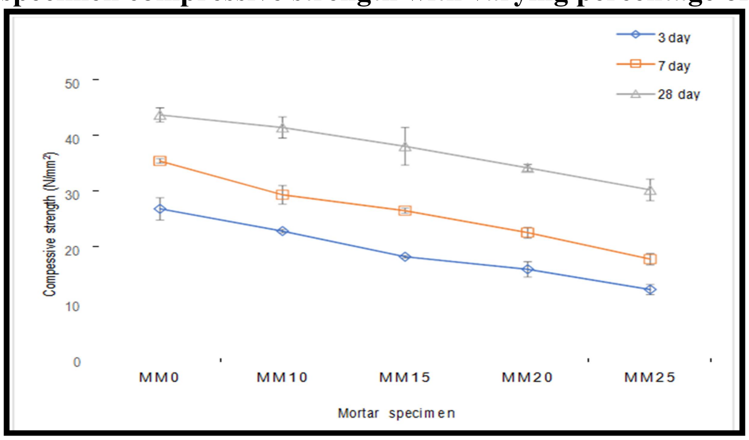
Compounds	%W/W	Elements	ppm
SiO_2	50.710	Cl	1306.832
Al_2O_3	17.830	Ba	735.445
Fe_2O_3	6.330	Cr	11.094
CaO	2.610	Zr	171.040
K_2O	3.580	W	169.557
MgO	2.580	Rb	183.939
Na_2O	1.090	Sr	76.591
TiO_2	0.620	Cu	78.012
P_2O_5	0.320	V	61.658
MnO	0.118	Ni	37.082
ZnO	0.020	Pb	50.993
Carbonaceous matter	13.876	As	60.735
		Ce	146.636

Mineralogical Characteristics **Thermal Composition**

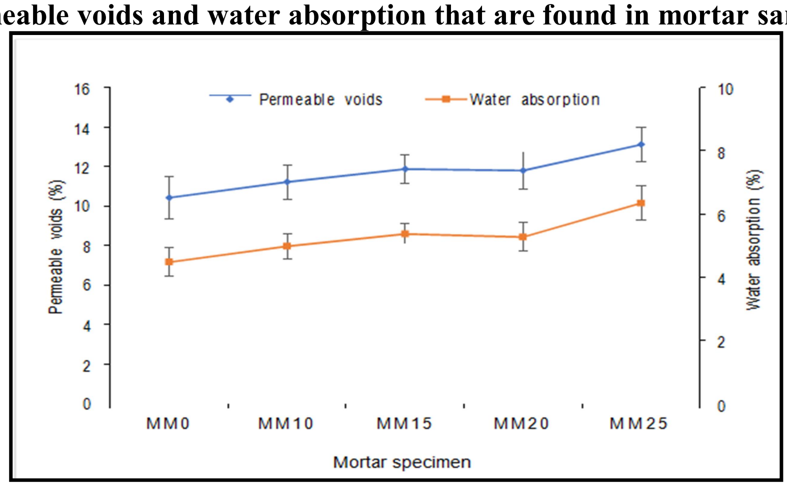




Mortar specimen compressive strength with varying percentage of CFBSS



Permeable voids and water absorption that are found in mortar samples



V. CONCLUSION

Prior to this study, sludge quantification had not been done or reported in such depth. The WTP was monitored for a full year, taking into account the effects of seasonal changes on raw water quality and, as a result, WTSs.

Physicochemical features of collectively generated after coagulation-flocculation and filtering of raw water have been documented in previous research.

However, in this study, CFS from the clariflocculator and FBS from the filtration unit were evaluated separately to see if there was a better way to use the waste/residue from the WTP.

In the construction industry, an unique strategy for utilising FBS in the form of CFBS has been presented and researched for beneficial reuses.

1. The pH of the incoming raw water changes slightly at WTP but remains close to the desired pH of 8.
2. The TSS and turbidity of entering raw water vary greatly throughout the year in the north-western section of India due to the direct influence of the seasonal transition.
3. The highest monthly average TSS and turbidity value was observed in July, the peak month of the monsoon, and the lowest in April, the pre-monsoon month. Because of significant rainfall and surface drainage on the upstream side of the raw water intake, the Ganga River is inundated in July and carries large volumes of sediments, sand, silt, mud, plant fibres, and other contaminants.
4. Seasonal variations in the quality of raw water have an impact on the monthly production of WTS at the water treatment plant, which varies throughout the year.
5. Because TSS and raw water turbidity are both at their highest in July, it is discovered that WTS output peaks during the monsoon season, peaking at 10,635 tonnes.
6. CFS has a lower proportion of silt and clay than FBS and a higher proportion of fine sand.
7. The main chemical components of CFS and FBS are silica, alumina, lime, and ferric oxide; however, alumina and ferric oxide are found to be about twice as abundant as FBS.
8. The TG-DTA study reveals a net weight loss of only 3.5 percent at 1000 °C, indicating that CFS is relatively stable. In comparison to CFS, however, roughly 9.38 percent of ignition losses occurred in FBS due to organic matter oxidation, phyllosilicate and aluminum hydroxide dihydroxylation, carbonate de-carbonation and dissociation, and other inorganic minerals.
9. Quartz is the primary crystalline mineral in the sludge, according to SEM and XRD investigations, and Al(OH)3 produces an amorphous precipitate.
10. In addition to quartz, the FBS mineral structure contains kaolinite minerals, albite, and calcite, which are also present in the CFS mineral structure.
11. Properties physicochemical FBS is proven to be appropriate for use as a raw material for the preparation of calcined clay pozzolana according to IS 1344:1981.
12. As the CFBS percentage increases, the amount of water required for standard cement and CFBS mixture consistency increases.
13. The use of CFBS to replace cement has only a minor impact on the initial set-up time. The ultimate setting time is only 1 hour longer when 20 percent CFBS is substituted in the cement. The time it takes for the final setting is likewise unaffected.
14. CFBS should have no effect on the hydration of the C3S and C3A, which are responsible for setting and hardening the cement paste.
15. Mortar specimens containing up to 20% CFBS have a compressive strength of more than 33 N/mm2.
16. The CFBS has been created to meet the Indian standard specification for pozzolana calcined clay, for incorporation into unmixed cement mortar and concrete and lime-pozzolana mixtures, and for the manufacture of Portland pozzolana cement.
17. The recycling of CFBS will be a cost-effective option for reuse in the

construction industry, while also paving the path for the long-term disposal of the waste/residues generated by the WTP filtration unit.

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