Enhancing Sludge Dewatering Process by Using Green and Environmental Wastes

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***Abstract* - Sludge dewatering is challenging due to sludge's highly compressible nature and the presence of colloidal particles. The capital, operating, and transportation expenses of wastewater management can be decreased by decreasing the amount of water content in the sludge. In the present study, the sludge samples were taken from municipal WWTP, with a moisture content of 98% and specific resistance to filtration (SRF) 1.2265E+16 m/kg. The samples were chemically conditioned with moringa Olivera at different dosages and physically conditioned with (rice husk and wheat straw) to improve sludge dewatering. The experimental work included evaluating the treated sludge's dewatering ability SRF. The results showed that the chemical coagulation affected the SRF of the sludge; the lowest values were 3.43296E+15 m/kg and time to filtrate (TTF) was 326.6 sec. However, when the rice husk and wheat straw were combined with chemical conditioning, noticeable improvements were noted in the sludge dewatering ability compared to the coagulation conditioning alone. The physical conditioners acted as skeleton builders during this pressure dewatering. The lowest SRF. were 1.62497E+15m/kg and 1.58377E+15m/kg for wheat straw and rice husk, respectively. Hence, the study recommends using rice husk or wheat straw for conditioning.**

Keywords: sludge dewatering, filter aid, specific resistance to filtration, time to filter, chemical conditioning, physical conditioning, rice husk.

I. INTRODUCTION

Water is the most valuable component of various human activities and industrial processes. Rivers, aquifers, reservoirs, lakes, and groundwater are continuously utilized for their water resources to meet the demands of both industrial and domestic consumers.[1] The continual consumption of huge quantities of water generates a considerable volume of wastewater. Due to the dangers it causes if discharged untreated wastewater into drainages and rivers, wastewater treatment is a pressing environmental concern.; Additionally, wastewater poses a significant threat to public health due to the pathogens it contains; as a result of the environmental interaction between wastewater, soil, water, and human health, effective wastewater management must be developed to mitigate these negative effects [2].

The purpose of wastewater treatment systems is to bring back to the greatest feasible to make it suitable for subsequent reuse and to have the least possible negative influence on the surrounding environment if discharged. Wastewater treatment plants produce enormous amounts of sludge, a hazardous waste that frequently contains a lot of water and organic matter [3]. Treatment and disposal of wastewater sludge are among the costliest processes performed by wastewater treatment plants worldwide. Somewhere between 30 and 40% of a treatment plant's initial investment and 50% of its ongoing operational expenses are attributable to sludge management [4].

Sludge conditioning can improve the sludge's capacity to be dewatered [5]. Sludge particles can be flocculated into larger particles or flocs through chemical conditioning, which can achieve this goal [6]. During the dewatering compression phase, the sludge is extremely compressible. Due to the high compressibility of sludge, the particles of sludge cake become distorted when they are subjected to high pressures after forming the cake. This deformation fills the cavities in the cake, decreasing the sludge's filterability [7]. Therefore, physical conditioners are commonly used to lessen the sludge's compressibility and improve the sludge's mechanical strength and permeability during compression. These conditioners are also referred to as skeleton builders or filter aids because of their role in sludge dewatering. These physical conditioners can generate a porous and more rigid lattice structure during mechanical dewatering, preserving porosity even under extreme pressure.

According to the literature review, the most used physical conditioners are lime [8], coal fly ash [9], gypsum [10], slag [11], wheat straw [12], rice husk [13], wood chips [14] and cement kiln dust [15].

Sludge dewatering capacity cannot be improved solely through physical/chemical conditioners [16]. Several studies on sludge dewatering with physical and chemical conditioners have improved sludge dewatering performance through increased settleability, the release of stored water, faster sludge filterability, and reduced sludge compressibility[17], [18]. As a result, it has been deduced that a combination of physical and chemical conditioners enhances the dewaterability of sludge. With this background, the present study attempted to investigate the efficiency of wheat straw and rice husk for sludge dewatering.

II. Materials and methods

2.1 Materials

2.1.1 Sludge. Sewage sludge was sampled from a municipal wastewater treatment plant in Ismailia, Egypt**.** The MC of the raw sludge was approximately 98%; the total solids (TS) ranged from 19400 – 20250 mg/L, and the pH values were between 6.90 and 7.3. The sludge sample was stored in a refrigerator at 4 °C to minimize microbiological action. Before proceeding with the experiments, the sample was extracted to reach a room temperature of 17 to 29 °C.

2.1.2 conditioners. Wheat straw and rice husk were used for physical conditioning. Moringa Olivera was used in the form of dry powder for chemical conditioning.

2.2 Methods

The most common sludge dewatering performance index is SRF and TTF. SRF is associated with the slope of the plot of T/V versus V (Eqn. (1)), TTF is the time needed for 100 mL of the filtrate to build up in the cylinder from 200mL sample

$$SRF = \frac{2*P*A^2*\alpha}{\mu*\omega} \qquad (1)$$

where: S.R.F., m/kg, P = applied vacuum, (N/m^2), A = area of the filter paper (m^2), α = slope of the T1/V versus V plot (sec/m^3), μ = viscosity of filtrate, taken as that of water (Pa.sec), ω = ratio of dry particles mass to filtrate volume (Kg/m^3).

Determining the optimum dose of the moringa sludge sample was treated with several concentrations of moringa for approximately 60 seconds at 300 rpm. Following conditioning, the sludge flocculated slowly at 80 rpm for 30 minutes. The SRF and TTF tests were applied using a Buchner funnel in a vacuum (Fig.1) [19] to 200 ml samples of conditioned sludge to determine Both the optimal dosage and the most valued conditioner for achieving the lowest SRF value.

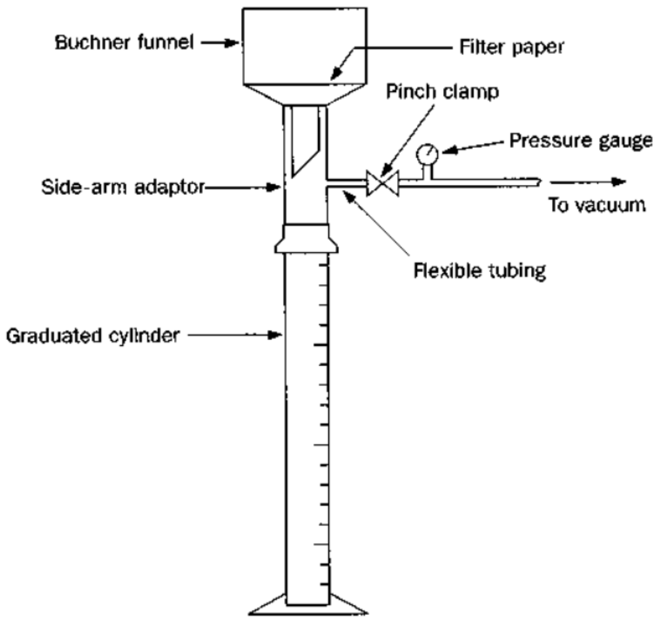

Figure 1: Filtration apparatus used for SRF and TTF tests

After adding the chemical reagents, the sample was rapidly mixed for 1 minute at 300 rpm. After adding the physical conditioner (wheat straw, rice husk), the mixture was rapidly stirred for 1 minute at 300 revolutions per minute. After that, we let the reactors spin at 80 revolutions per minute to slowly mix the contents. The sludge was brought to the FCC [20] (Fig.2) after conditioning. Following the dewatering process, the pressure was released, and the products were taken out of the system for further examination.

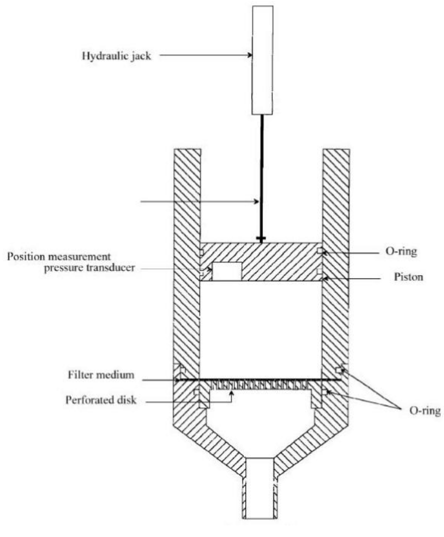

Figure 2: Filtration apparatus used for SRF test

2.3 Performed tests

Analysis of sludge samples was performed using "Standard Methods for the Examination of Water and Wastewater" (Federation & Association, 2005).

III. RESULTS AND DISCUSSIONS

3.1 Effect of chemical conditioning on sludge dewatering

The effect of moringa on reducing SRF for conditioned sludge was studied; a comparison was conducted to get the best coagulant that reduces the SRF and TTF values. The reduction of SRF values showed that conditioning the sludge with moringa can improve the dewatering capacity.

Fig.3 & Fig.4 demonstrate that moringa can enhance dewatering of the sludge under the optimum dose of 6 g/L. where the lowest SRF was 3.43296E+15 m/kg and TTF was 326.6 sec. The results agreed with [21], who found that 4750 mg/L Moringa oleifera in water solution form and 6000 mg/L dry powder Moringa oleifera were the optimum dosages in sludge conditioning.

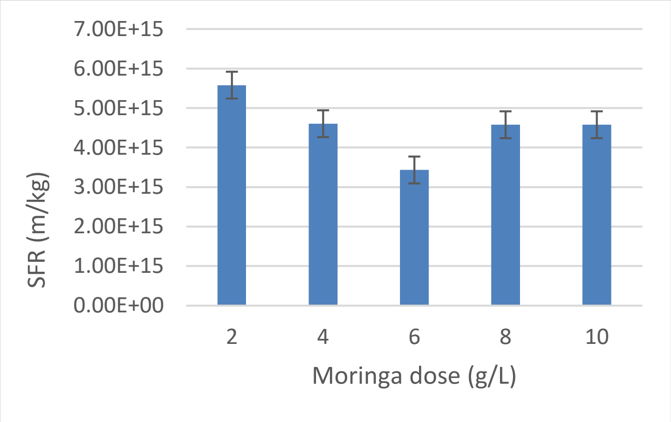

Figure 3: Effect of coagulants doses in S.R.F. values

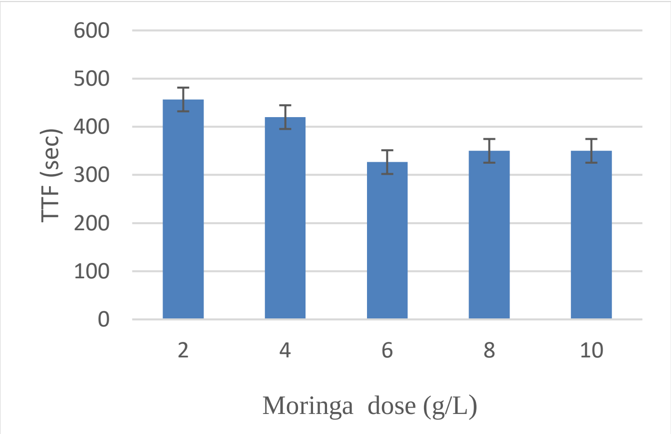

Figure 4: Effect of coagulants doses on TTF values

3.2 Effect of physical conditioning on sludge dewatering

With the help of moringa, investigations were conducted on the pressure filtering method of sludge. To test the effectiveness of the physical conditioners on the chemically conditioned sludge sample the filtration compression cell (FCC) was chosen as a mechanical dewatering procedure. During the tests, the greatest attention was focused on specific filtration resistance (SRF). Having a lower SRF resulted in better dewatering performance and vice versa.

3.2.1 Effect of adding rice husk on sludge dewatering

When the dewatered sludge was utilized as fertilizer, rice husk was considered an organic conditioner with no detrimental environmental effects. We employed rice husk at different doses ranging (from 20%- 150%) dry solids (DS) to investigate the impact of rice husk as a physical conditioner on sludge dewatering performance. The rice husk was separated into four sizes using a sieve: 75 microns, 150 microns, 300 microns, and 600 microns. This was done to estimate the optimal dose for the best diameter.

Fig.4 showed that the least SRF was obtained at 600-micron diameters. Fig.5 showed that increasing the rice husk dosage caused the SRF value to drop to 1.58377E+15m/kg. What this means is that dewatering efficiency is increasing. Therefore, rice husks can be utilized as physical conditioners since they can operate as skeleton builders, decreasing the compressibility of the conditioned sample.

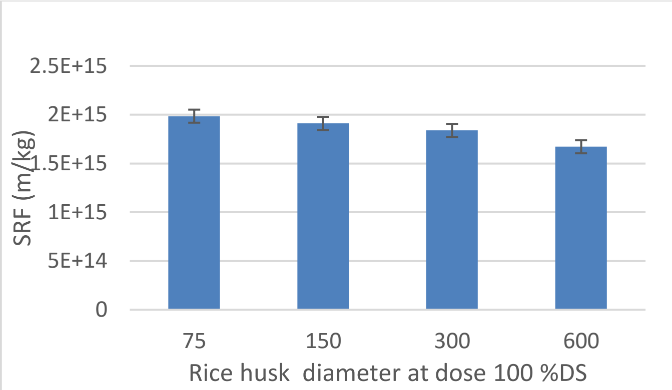

Figure 5: Effect of rice husk diameters on SRF values

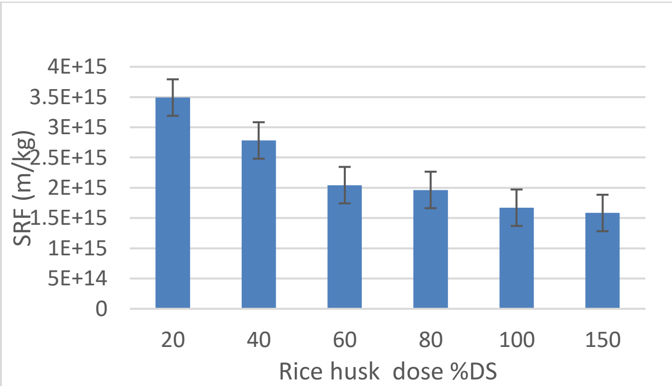

Figure 6: Effect of rice husk dosages on SRF values

Figure 7: conditioned sludge sample after dewatering

3.2.2 Effect of adding wheat straw on sludge dewatering

As rice husk, wheat straw has no detrimental effects on the environment if the dewatered sludge used as fertilizer. Different doses were applied to study wheat straw's effect on sludge dewatering, ranging from (20%- 150%) DS. The wheat straw was separated into four sizes using a sieve: 75 microns, 150 microns, 300 microns, and 600 microns. This was done to estimate the optimal dose for the best diameter.

Fig.7 showed that the optimum diameter was found to be 600 micros. Fig.8 showed that increasing the wheat straw dosage caused the SRF value to drop to 1.62497E+15 m/kg. What this means is that dewatering efficiency is increasing.

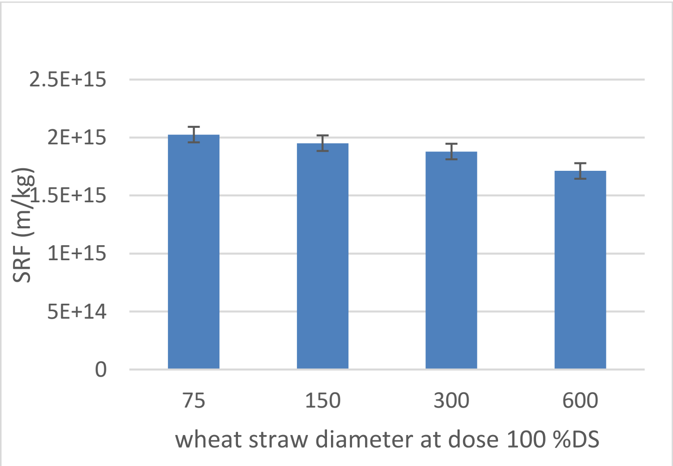

Figure 8: Effect of wheat straw diameters on SRF values

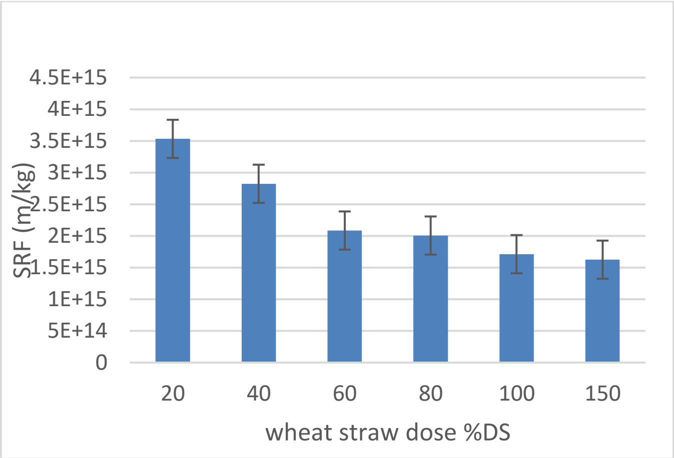

Figure 9: Effect of wheat straw dosages on SRF values

Figure 10: conditioned sludge sample after dewatering

IV. CONCLUSION

- Chemical coagulation with moringa affected the sludge's SRF (in Buchner funnel). The lowest SRF was 3.43296E+15 m/kg and 185.28 for moringa dosage 6 g/L.
- The rice husk and wheat straw acted as skeleton builders during this pressure dewatering in FCC. The lowest SRF was 1.58377E+15m/kg and 1.62497E+15m/kg, respectively, when the dosages of moringa, rice husk, and wheat straw were 6 g/L and 150% DS, respectively.
- Rice husk and wheat straws can be utilized as physical conditioners since they can operate as skeleton builders, decreasing the compressibility of the conditioned sample of sludge.

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