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PRODUCTION OF SOIL-CEMENT BRICKS USING SLUDGE AS A PARTIAL SUBSTITUTE

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ABSTRACT

Water treatment plants (WTP) produce copious quantities of solid waste in the form of sludge that is deteriorating water resources, agriculture lands and human health. It should be discarded properly but a grave issue is finding ecological solution for its ultimate disposal. This study will provide an idea of incorporating sludge into soil-cement bricks that are used for construction providing dual benefits: reducing amounts of sludge and introducing cheaper bricks. A sample of sludge was analyzed for chemical constituents, plasticity value, particle size and content of organic matter. Sludge bricks incorporating 10 % of waste material by weight were prepared. The quality of sludge bricks was evaluated in terms of mechanical and physical properties (compressive strength test, water absorption test and apparent density test). The obtained results have revealed that waste material is mostly composed of plastic and could be utilized for manufacturing of sludge bricks. The compressive strength and density of bricks reduced with increasing amounts of sludge. However, the compressive strength of the bricks could even meet the standard requirement.

1. INTRODUCTION

Discharge of industrial and domestic waste water is a big problem as it effects fresh water resources, agriculture production and human health [1]. A particular phenomenon that contributes huge amounts of pollutants (solid waste) is water treatment plants (WTP) [2,3]. Generally, municipal effluent from treatment plants is finally disposed in nearest water systems without handling methodology. This problem contributes to environmental disturbances as enlarging quantity of solid waste, risk to aquatic life, sedimentation, changes in the turbidity and color, increase metals concentrations in waste, finally causing public health problems [4].

Finding an environmental friendly destination for final disposal of waste from treatment plant is a critical issue. Concerning the disposal of effluent of water treatment plants, many techniques are utilized like landfill, composting, thickening, application as fertilizer or soil conditioner, incineration, and digestion (Anaerobic & Aerobic). In 1980s, sludge had been reused for making fired clay bricks with satisfactory compressive strength [5]. Latterly, incorporation of sewage sludge was itemized to create good performance blocks and has replaced sand up to 10% with sewage sludge [6]. Several wastes are reused as a substitute of fine aggregates with cement for making concrete blocks which mostly includes CRT funnel glass, marble waste and ferrochromium slag [7-9].

Some recent studies evaluated the possibility of using dried sludge of lime as a substitute to limestone in clinker production and reusing the waste slurry of marble as partial replacement of cement in production of concrete [10,11]. Another study evaluated that integrating sludge less up to 20% by mass may produce quality concrete bricks with satisfactory mechanical properties [12]. Pavement blocks, flooring tiles, burnt clay bricks, solid blocks, and hollow blocks has been produced by using 10%, 20% and 30% as substitute to cement with effluent [13]. As presented in literature there are few studies found on utilization of effluent sludge from WTP in production of soil cement bricks.

Present work investigates the feasibility of incorporating effluent from WTP into sample bricks. These sludge bricks are economical and considered environmental friendly, because as compared to conventional clay brick formation there is no firing step involved in its formation. Additionally, in developing countries sludge bricks are very much attractive in construction of small houses.

2. MATERIAL AND METHODS

2.1 Experimental Procedure

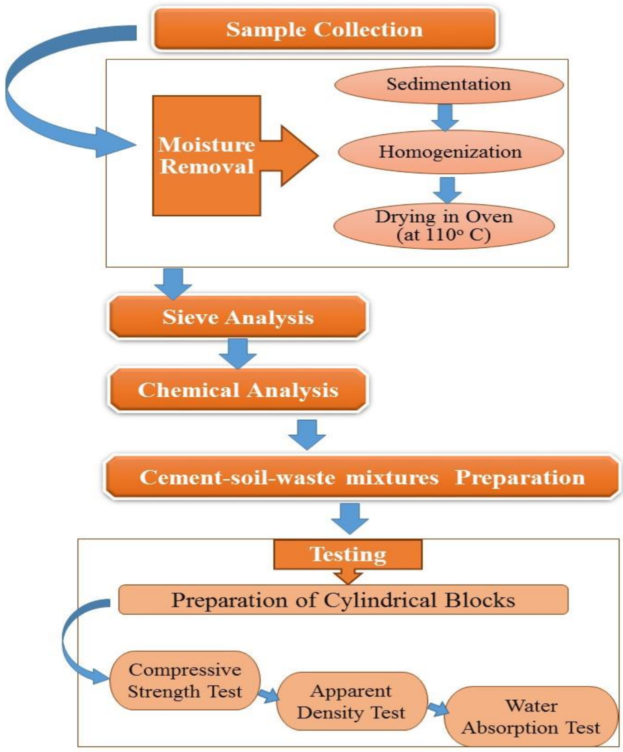

Figure 1: Sketch of experimental procedure

The experimental sample of effluent was collected from Chakera treatment plant Faisalabad, Pakistan. Excess water of waste sludge was removed through sedimentation and remaining material were homogenized (Figure 2.0). This raw effluent was dried in an electric oven

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at 110 °C for 48 hours and passed through 35 mesh (425 µm ASTM) sieve until a fraction is collected. The whole experimental procedure is shown in Figure 1.

Figure 2: Raw effluent of water treatment plant

X-ray spectrometer was used for chemical analysis of collected sample. Standard procedures were used to determine particle size. Walkley-Black test was used to calculate organic matter content [14].

Cement-soil-waste mixtures with 10 % by weight of waste as a fractional substitute of cement and with 20% by weight of water were prepared (Table 1.0). Common ratio of Commercial soil and Portland cement (4:1) was take as reference. For testing cylindrical blocks made by uniaxial pressing were prepared (18 MPa), these blocks have been cured in chamber at 24°C and at 95% humidity for 28 days.

Table 1: Samples with different compositions

Samples	Soil (%)	Waste (%)	Cement (%)
A1	100.00	0.00	25.00
A2	100.00	2.5	22.50
A3	100.00	5	20.00
A4	100.00	7.5	17.50
A5	100.00	10	15.00

Standard procedures were adopted to determine following technological properties of bricks: compressive strength, water absorption and apparent density [15,16].

3. RESULTS AND DISCUSSION

The chemical constituents of waste sample along with loss on ignition are showed in Table 2. It is perceived that the waste is mainly composed of Al_2O_3, SiO_2 and Fe_2O_3 (about 71%). The value of loss on ignition of (at 1000 ºC) observed sample was high (25.23% by weight). This is mainly due to dehydration of the hydroxides, water loss from clay minerals, and due to decomposition of organic matter. Organic matter present in high concentration in waste sample (24.85 %).

Table 2: Chemical composition analysis of sludge sample

Compound	Weight (%)
Al_2O_3	30.8682
SiO_2	28.7023
Fe_2O_3	10.7205
TiO_2	1.0504
K_2O	1.2954
SO_3	1.5617
CaO	0.3366
ZnO	0.0196
MnO	0.1386
Loss on ignition	25.235

Particle size of water treatment plant waste sample ranges largely (1 to 550 µm), with mean value of about 4 µm. It was observed that the amount of clay fraction (of size almost 2 µm) is high (about 40%). The high amounts of clay proportion of the waste is essentially favors the use of waste as an alternative in the sludge bricks. This high percentage of clay is very exasperating to the homogeneous behavior, due to which hydration process of cement might affected [14].

Waste sample exhibit large value of plasticity with Atterberg plastic index of 26.5 % and it is interrelated with the distribution of data of particle size. Additionally, this value recommended that the sludge waste can be utilized for manufacturing Sample bricks, as its small fraction is used.

Figure 3. shows graphical results of compressive strength values of tested samples (cured for 28 days) against sludge waste proportion. Maximum compressive strength observed with no sludge proportion (4.5 MPa) and shows a declining trend with waste addition as compressive strength is minimum (3.5 MPa) at maximum proportion of waste that is 10%. Although, compressive strength values of manufactured bricks are even greater than standardized value (>2 MPa), which favours the use of these bricks in construction [17].

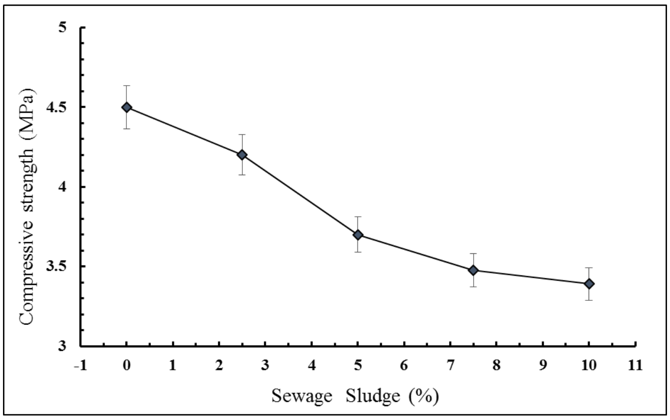

Figure 3: Compressive strength values of tested sample blocks

Figure 4 graphically presents the trend of apparent density values of tested sample blocks combined with sludge. It is interpreted that with increasing sludge proportion, there is a trend of decreased value (1.72 to 1.53 g/cm³) of the apparent density. It is clearly can be seen that the declining trend is almost linear.

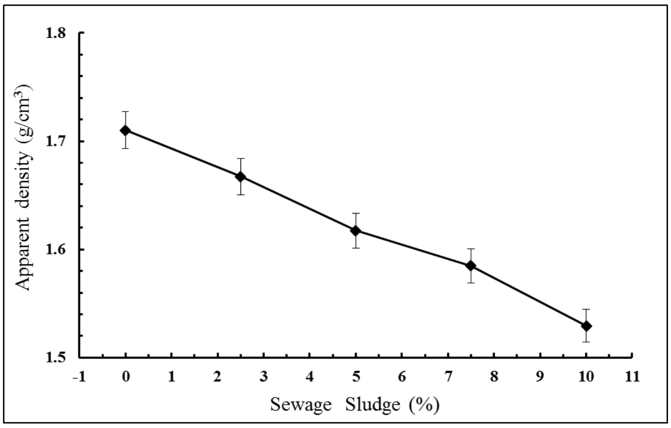

Figure 4: Apparent density trend of the Sample blocks

Figure 5.0 displays the observed values of water absorption of samples with sludge proportion. It is noticed that the capacity of absorbing water of sludge bricks is highly affected by addition of waste. Graph exhibits the direct relation of waste percentage with water absorbing capacity, as with addition of waste the water absorbing capacity increases. This trend favors the statement that sludge sample has high ratio of clay proportion

(40 %) and plasticity value (Atterberg plastic index = 26.5%), that largely effects hydration reactions of cement. The sludge grips large amounts of water, so it lacks adequate water to complete hydration process of cement. Although, the water absorbing capacity of sludge bricks does not exceeds standard value (20 %) [17].

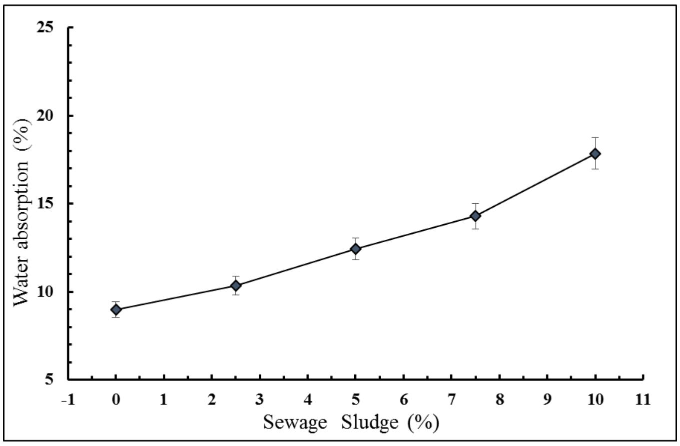

Figure 5: Water absorption values of Sample blocks

4. CONCLUSIONS

The solid waste (sludge) from treatment plant is a plastic material (Atterberg plastic index = 26.5 %) rich in Al_2O_3, Fe_2O_3, SiO_2, and organic matter. In present study, it was experimented that the sludge can be used as a substitute of soil up to 10 % in formation of sludge bricks. The quality checks (Apparent Density, Compressive strength and Water absorption capacity) showed that sludge bricks meet the standard requirements and can be used for construction purposes. Only limitation is associated with the increment in water absorbing capacity of sample bricks. In spite of this, the integration of sludge waste in the bricks production is of an exceptional substitute to reuse of solid waste of wastewater treatment plant.

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