Asian Journal of Applied Science and Technology (AJAST)
(Open Access Quarterly International Journal) Volume 2, Issue 2, Pages 981-986, April-June 2018

A Review on the Retainment of Soil Water by Addition of Low Carbon Foot Print Biopolymer

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Article Received: 27 February 2018 *Article Accepted: 29 April 2018* *Article Published: 08 June 2018*

ABSTRACT

Enhancing soil Physical and Engineering properties of soil by the addition of external supplements is the traditional method which includes the adding of Lime and Cement. As the carbon footprint of these additives is so high the focus turned towards Natural and Environmental friendly additives. By increasing the bond between fine particles and coarse particles effects particle whole size to retain more water. apertures od soil play a vital role in this process as it is providing void space for Gases and Moisture to channel. Present study mainly focused on Biodegradable, Renewable and cheaper Biopolymer and biochar which will form a biofilm barrier on the soil to improve the water retention capacity.

Key words: Biopolymer, Biochar, Carbon Foot Print.

1. INTRODUCTION

Water holding capacity is the important characteristics of soil as it effects the retainment of nutrients. Along with water the nutrients are attached to the soil, if the water retainment capacity is less that soil will reach the saturation point very soon and the remaining nutrients are leached away from the soil. Physical properties like Texture of soil, Particle Size, permeability and soil organic matter. Soil structure play a major role in maintaining void space in the soil which effects root growth and air and water movement. The water retainment has measured in terms of particle size. Depending on particle size soil is being categorised in to Sand (2.0-0.05 mm), Silt (0.05-0.002 mm) and Clay (< 0.002 mm). As the particle size decreases the effective surface area increases to improve the water retainment of soil. Permeability of soil effects the movement of water and air in a soil. If permeability is high water moves quickly.

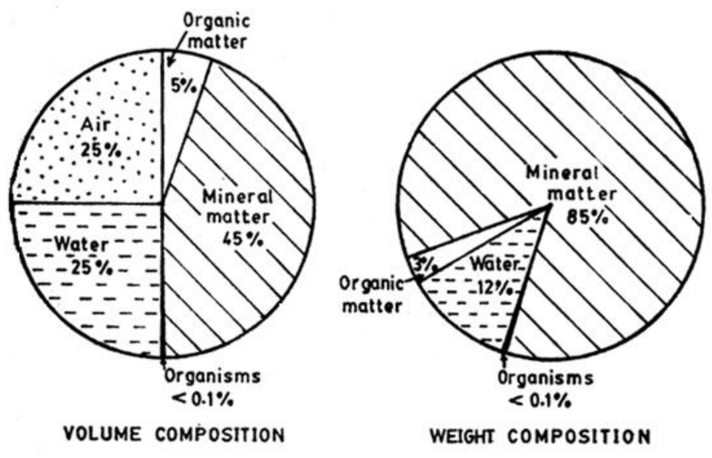

Fig 1: Soil structure

Different methods were adopted traditionally to improve the physical and engineering properties of soil like addition of Lime, Cement, Biochar and new methods which include modification by the addition of Biopolymers.

Stabilization of soil is very significant but the study on environmental impacts after addition is also important. While considering the environmental impacts of chemical stabilization methods, studies should concentrate on the effects after the application of the chemical as well as the process involved in the production of these chemicals. Studying the impact of soil stabilization using cement will first point to the impact at the time of production of cement. The total quantity of green house gases out per ton of Biopolymer modified soil: prospects of a promising green technology cement production is in the tune of 0.95 tons (Biju et al., 2016). With this the matrix stabilization which prevents the growth of vegetation on the top soil proves that cement stabilization is not a green technology. The extensive utilization of cement cause quite a lot of related issues in the habitat, such as increased runoff, air pollution and heat island. Moreover, it is not easy to return cement modified soil to their initial state (Chang et al., 2016). New technology having more advantages over old as the carbon foot print of biopolymer is less as compared.

The water retention capacity of a soil is a very important agronomic characteristic. The retainment water is very important to avoid leaching of nutrients. Soils that hold generous amounts of water are less subject to leaching losses of nutrients or soil applied pesticides. This is true because a soil with a limited water holding capacity (i.e. a sandy loam) reaches the saturation point much sooner than a soil with a higher water holding capacity (i.e. a clay loam). After a soil is saturated with water, all of the excess water and some of the nutrients and pesticides that are in the soil solution are leached downward in the soil profile (Saritha et al., 2014).

In the past 100 years, many laboratory methods have been developed around the world to determine soil water holding capacity. These methods use a variety of special apparatus to determine how much water a soil will hold under various conditions. Most of these methods start with a water saturated soil sample. The saturated sample is placed on a porous ceramic plate which is then placed in a closed chambers.

Water Holding Capacity

Six Methods Using Ceramic Pressure Plates
% Water Holding Capacity of Four Soil Samples

Bars of Atmosphere	cm of Water	Pf Units	Loamy Sand	Loam	Silt Loam	Clay
Pressure Applied to Plate						
0.001	1	1.000	28.7%	71.3%	69.9%	69.7%
0.1	102	2.009	17.2%	32.5%	50.4%	42.8%
0.333**(*)	340	2.532	12.0%	26.8%	40.1%	34.5%
1.0	1020	3.009	8.6%	23.0%	30.5%	28.2%
5.0	5099	3.708	6.0%	20.0%	23.5%	21.7%
15**	15297	4.185	5.2%	19.0%	23.4%	20.1%

** These are the two most commonly requested methods

Water Holding Capacity

Two Alternative Methods
% Water Holding Capacity of Four Soil Samples

Alternative Method Name	Loamy Sand	Loam	Silt Loam	Clay
0 Bar (no pressure applied)	29.4%	85.1%	71.9%	73.7%
Maximum Water Holding Capacity (European Method)	26.9%	42.5%	48.9%	39.1%

Fig 2: water holding capacity chart for different samples

A known amount of pressure is then put into the chamber, which forces water out of the soil sample and into the porous plate and out of the chamber (see 1/3 Bar picture). The water holding capacity of the soil is determined by the amount of water held in the soil sample vs. the dry weight of the sample. The amount of pressure applied in these different methods can be as low as 1/3 atmosphere of pressure (about 5 psi) up to 15 atmospheres of pressure (about 225 psi).

The usage of biopolymers for soil enrichment in agricultural, construction, and military applications have been recognized by many researchers. Better usage of these materials for soil improvement requires knowledge about interaction mechanisms involved in the modification of geotechnical properties of soil. Low concentrations of synthetic- or bio-polymers in irrigation water can nearly eliminate sediment, N, ortho- and total-P, DOM, pesticides, micro-organisms, and weed seed from runoff (Sojka et al., 2005). Most of the studies in clay polymer interaction are from the field of medical engineering, where clay particles are suspended in the colloidal form and macromolecules are attached to them in different ways (Biju at el., 2016). The present work discuss mainly about different methods are available for the production of biopolymers and their applications.

2. METHODS OF BIOPOLYMER

Biopolymers that have been tested for use in soil stabilization include cellulose, starch, chitosan, xanthan, curdlan, and beta-glucan (Orts et al., 2000)

2.1. Cellulose and starch

Cellulose ($C6H10O5$)n is abundantly present in nature. It consists of β-(1 Ñ 4)- D -glucose linkages, and is the main component in the cell walls of plants, and has the longest history of utilization in engineering. In addition, organic compost containing high cellulose content has been reported to induce higher soil aggregate stability by increasing water repellency (Annabi et al., 2007).

2.2. Xanthan Gum

Xanthan gum is a polysaccharide that is made by the Xanthomona scampestris bacterium, and is generally used as a viscosity thickener due to its hydrocolloid rheology. Xanthan gum has been introduced to geotechnical engineering to reduce the hydraulic conductivity of silty sand via pore filling as well as to increase the undrained shear strength of soil by increasing the liquid limit. An other recent study has studied possibilities for using xanthan gum as a soil strengthener, and showed that xanthan gum preferentially forms firm xanthan gum-clay soil matrices hydrogen bonding.

2.3. Agar Gum

Agar gum is a polysaccharide that is composed of linked galactose molecules, and is extracted from rhodophyceae (Ivankv et al.,2008). Agargum has rheological properties that make it useful as a thickener, stabilizer, and emulsifier. Moreover, agar gum has a thermogelation property that allows the formation of strong gels when cooled back to room temperature after being dissolved in boiling water.

2.4. Gellan Gum

Gellan gum is a high molecular weight polysaccharide fermented from Spingomonas elodea (formerly known as Pseudomonas elodea) microbes [107]. A recent study showed that 3%of gellan gum dispersed within a clay soil exhibited a maximum unconfined compressive strength of 12.6 MPa. Although gellan gum has a similar gelation rheology and strengthening effect to agar gum, gellan gum is preferred for future mass commercialization because it can be easily produced via microbial fermentation, whereas agar gum has to be extracted from seaweed (i.e., algae).

3. RESULTS AND DISCUSSION

Polyacrylamide was effective in enhancing the stability of soil aggregates (Steven Green et al, 2004) and increase soil infiltration in some areas especially in sandy loam soils (Steven Green et al, 2000; Hussein and Thomas, 2006). Polyacrylamide is a long-chain synthetic polymer that acts as a strengthening agent, binding soil particle together and holding soils in place, but Polyacrylamide alone not remediate poor soil Structure, (Cook and Nelson, 1986). Acid - hydrolyzed Cellulose micro fibrils alternative to Polyacryalamide for soil stabilization was tested and show promises (Orts et al, 2007). PAM, applied in furrows as a powder patch, reduced sediment in runoff 37, 97 and 98% for 7.5, 15.0 and 22.5 L min21 flows from a 40m field (Entry and Sojka, 2003). Low control treatment erosion at the 7.5 L min21 flow rate accounted for the greater relative erosion reduction at higher flows (Sojka et al., 2005). 2-4 % (w/w) of polystyrene film was prepared by dissolving 5-10 g of polystyrene in 250 ml of toluene under continuous stirring (300 rpm); after filtering the polymer was cast at temperature between 50-60°C then removed from the mould and stocked at 23 ±2 °C. the amount of water retained by semi arid soil and arid soil increased by adding small amount (0.03%-1%) of polymer and biopolymer to the soil. The semiarid soil treated with polymers and biopolymers showed better growth than in control or with only polymer or only biopolymer (Maghchiche et al., 2010). Two types of biopolymers were (xanthan gum and guar gum) used in this study due to their stable behaviors under severe conditions and their availability with reasonable prices. The results indicated that the ability of both xanthan gum and guar gum can be used as improvement materials for collapsible soil treatment. The collapsible potential has been reduced from 9% to 1% after mixing the soil with 2% biopolymer concentration in the wet case (Ayeldeen et al., 2016).

The effect of the hydrogel amendment on the moisture release curve of a sandy texture soil. A typical sandy soil(91.5% sand, 4.2% silt and 4.3% clay) from an agricultural area A phytotoxicity test and two cultivation trials were carried out to evaluate the absence of phytotoxicity of the hydrogel and the effects of growing medium (soil or soilless substrate) amended with hydrogel on growth and physiological traits of plants. The presence of the polymer in the sandy soil dramatically altered the soil water holding capacity At a suction pressure of pF 2.0 (-0.1 bar), hydrogel at the lowest dose nearly doubled the moisture content of the not amended soil, while at the highest hydrogel dose the water content exceeded 50%, which is even higher than a clay soil with a good structure characterized by considerable water retention capacity (Montesano et al., 2015).

xanthan gum is added to the sample. For example, addition of just 0.5% xanthan gum to the sand decreases the permeability to almost 0.001% of the initial value. Addition of 1.5% xanthan gum changes the permeability from 8.46 · 10–5 m/s to about 2.84 10–11m/s, which is less than 1,000,000 times (Wiszniewski et al., 2013).

Chitosan to a clay soil could enhance the interparticle cohesion and therefore increase the mechanical properties of the matrices; however, this mechanism is affected by two major factors of moisture content and curing durations. In a soil specimen which subjected to wet conditions (optimum water content and saturated states), chitosan acts as a cohesive agent to enhance the bond of soil particles at early ages; while, it loses its efficiency due to the hydro degradability over time (Hataf et al., 2017)

4. CONCLUSION

1. Enhances plant growth which absorbs more co2 from atmosphere.
2. Increases water retention capacity of soil.
3. Biochar increases microbial activity of the soil.
4. Turning agriculture waste into biochar also reduces methane.
5. generated by natural decomposition of waste.
6. Causes less pollution when compared to other fertilizers.
7. Reduce the nutrient loss due to leaching.
8. Mitigation of root damage by high concentration of salt.
9. Reduction in production cost.

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