THE EFFECTIVENESS OF SODIUM POLYACRYLATE AS LANDSCAPE CATALYST

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ABSTRACT

Sodium Polyacrylate is a component of Super Absorber Polymer (SAP) found in disposable diapers and act as catalysts in soil, which beneficial to serve as water retention for landscape. The study was to identify the growth parameters of Tecoma Stans and investigate the effectiveness of SAP as landscape catalyst. In 2012, Malaysia population is 28.3 Million and generated 33,000 ton/d solid waste. From the amount of waste generated, 12.14% (4006.2 ton/d) is comprised of disposable diapers dumped in landfill. By recycling these diapers will reduce the volume of waste into landfill and simultaneously reduces the impact of pollution to environment while saving economic factor. The study involved 5 different samples with SAP mixture (NHRN 2,3,4,5,6) and control sample (NHRN 1) during 11 weeks of study. The plant growths measured in morphological parameters were numbered of leaves, number of flowers, and diameter of stem and height of plants. Finding shows the positive growth in all samples with SAP compared to control sample. The increment of diameter stem for sample NHRN 1 (46.672%), NHRN 4 (138.89%), NHRN 5 (164.29%) while increment of height in NHRN 1 (39.56%), NHRN 4 (49.43%), NHRN 5 (88.86%), increment number of flowers in NHRN 1 (2100%), NHRN 4(4300%), NHRN 5 (9400%) and increment number of leaves in NHRN 1(154.17%), NHRN 4 (283.61%) and NHRN 5 (517.98%) simultaneously. Among all samples obtained, NHRN 5 demonstrates the best in all aspects of growth. In conclusion, these studies able to prove that SAP from disposable diapers, can benefit planting Tecoma Stans as a landscape catalyst.

***KEYWORDS**: Catalyst, Super Absorber Polymer, Water Retention, Disposal Diapers, Tecoma Stans.*

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1.0 INTRODUCTION

Catalysts are added as soil amendments to improve its physical properties such as water retention, permeability, water infiltration, drainage, aeration and structure. The goal is to provide a better environment for roots commercial enzyme treatments for soils are often advertised as having a large number of beneficial effects, including improved structure, nutrient "activation," greater nutrient availability, "detoxification" of the soil,better drainage, better water retention, and greater microbial activity. Therefore, an amendment must be thoroughly mixed into the soil. If it is merely buried, its effectiveness is reduced, and it will interfere with water and air movement and root growth. Many organic amendments contain plant nutrients and act as organic fertilizers. Organic matter also is an important energy source for bacteria, fungi and earthworms that live in the soil. Ideally, the landscape and garden soils improve to 4-5% organic matter.

In agricultural fields, polymers are widely used for improving irrigation efficiency; SAP materials have smart delivery systems that can help the agricultural industry to combat viruses and other crop pathogens. Functioned polymers were used to increase the efficiency of pesticides and herbicides, allowing lower doses to be used and to indirectly protect the environment through filters or catalysts to reduce pollution and cleanup existing pollutants (Ekebafe et.al.,2011).

A study by yhe Department of National Solid Waste Management, Ministry of Urban Wellbeing, Housing and Local Government in 2012, indicates that Malaysia by a population of 28.3 million generates 33,000 ton/d of solid waste. From the amount of waste generated, 12.14% (4006.2 ton/d) is comprised of disposable diapers (Nadzri, 2014). It shows that waste generation of disposable diapers is continuously increasing every year.

The study was done in order to achieve several key objectives and to provide the benefit to all levels of society. The objectives of the study are to identify the growth parameter of Tecoma Stan as a garden plant, examine the effectiveness of SAP as landscape catalyst and to investigate the most suitable sample of garden catalyst relate to SAP. Disposable diapers used are from a child's diaper.

Diapers are taken from kindergarten and lecturers quarters of the Polytechnic Sultan Idris Shah. Super Absorbent Polymer (SAP) from the disposable diapers are used in tree planting, lowering plant called Yellow Bell tree, or its scientific names " Bignoniaceae Tecoma Stan" play as an absorption response of soil to see the growing scale of the tree.

2.0 LITERATURE REVIEW

2.1 Plant Catalyst

Plant catalyst is known as a nutrient absorption enhancer. It makes ordinary water to become more reactive and more effective as a transport medium and improves the uptake and assimilation of nutrient and helps to improve physical properties of soil. The physical properties of the soil are water retention, permeability, water infiltration, drainage, aeration, and soil structure.

Soil water retention is a major soil hydraulic property that governs soil functioning in ecosystems and greatly affects soil management. Soil moisture forms a major buffer against flooding and water capacity in the subsoil is a major steering factor for plant growth. The effects of changes in soil water retention depend on the proportions of the textural components and the amount of organic carbon present in the soil. At low carbon contents, an increase in carbon content leads to an increase in water retention in coarse soils and a decrease in fine-textured soils. At high carbon contents, an increase in carbon content results in an increase in water retention for all soil textures. Generally, water retention is inversely related to permeability. Permeability is the property of rocks that is an indication of the ability of fluids (gas or liquid) to flow through rocks. High permeability will allow fluids to move rapidly through rocks. Permeability is affected by the pressure in a rock.

Infiltration is the process by which water on the ground surface enters the soil. The infiltration rate in soil science is a measure of the rate at which soil is able to absorb rainfall or irrigation. It is measured in inches per hour or millimeters per hour. The rate decreases as the soil becomes saturated. The rate of infiltration can be measured using an infiltrometer. Infiltration is governed by two forces: gravity and capillary action. While smaller pores offer greater resistance to

gravity, very small pores pull water through capillary action in addition to and even against the force of gravity. The rate of infiltration is determined by soil characteristics, including ease of entry, storage capacity, and the transmission rate through the soil. The soil texture and structure, vegetation types and cover, water content of the soil, soil temperature, and rainfall intensity all play a role in controlling the infiltration rate and capacity.

Soil drainage refers to the soil's natural ability to allow water to pass through it. Dense soil will hold water, while loose soil will allow water to pass through quickly. Soil drainage may determine which types of plants grow well in it. Clay soil is a very dense type of soil. Its particles are closely packed together and clay generally does not allow water to drain through. This type of soil slowly releases air and allows water to seep down into it. Clay soil generally sits on top of a solid rock bed. Roots that sit in standing water for long periods of time will become prone to disease and fungus and may wilt and die. Sandy soil is very loose. Its particles allow for the passage of both water and air. This soil drains water very quickly, which allows air to circulate around the plants within it. This can also cause the plants to dry out and some varieties grown in sandy soil may need to be watered more frequently for this reason.

Aeration involves perforating the soil with small holes to allow air, water and nutrients penetrate the grass roots. This helps the roots grow deep and produce a stronger, more vigorous lawn. The main reason for aerating is to alleviate soil compaction. Compacted soils have too many solid particles in a certain volume or space, which prevents proper circulation of air, water and nutrients within the soil. Excess lawn thatch or heavy organic debris buried under the grass surface can also starve the roots from these essential elements. Aeration will result in increased yields on a limited number of soil types that have hard pans and compacted layers; therefore, other areas of management will usually pay large dividends.

Structure refers to the arrangement of soil particles. A well-developed structure, usually indicates the presence of clay. Soil structure is classified into various classes. There are three major classes and several sub-classes. They are as follows: Structure less which includes Single grain and Massive; with a structure which includes Granular, Platy, Wedge, Blocky, Prismatic, and

Columnar; and Structure Destroyed which includes Puddled. The soil structure is of particular importance in the absorption of water and the circulation of air. A desirable structure should have a high proportion of medium-sized aggregates and an appreciable number of large pores through which water and air can move. There are three very important aspects of soil structure. Firstly, they are the arrangement into aggregates of a desirable shape and size, secondly the stability of the aggregate, and finally the configuration of the pores. This crusting greatly affects seeding emergence, and increases runoff and erosion.

2.2 Disposable Diapers

A disposable diaper consists of an absorbent pad between two sheets of non-woven fabric, one of which is permeable and another layer is impermeable. The pad is comprised of a hydrophilic polymer and a fibrous material, leading to maximum absorption capacity (Sarhanis et al., 2011). Chemicals are a concern for any parent that uses disposable diapers. The chemical Sodium Polyacrylate is found in disposable diapers and can absorb up to 1,000 times its weight, which makes the diaper able to hold so much urine. This is what those beads are that might appear in your child's diaper after a long night. This chemical has the potential to cause skin and lung irritation and redness of the eyes.

As shown on the Figure 1, most of the mass of a discarded used diaper (assuming proper flushing of solids) is urine, while the presence of super absorbent polymer (SAP) is the second lowest percentage with 6% by the weight of disposable diapers. Generally, the greater amount of mass of super absorbent polymer (SAP) contains in a disposable diaper, the lower the mass of paper pulp based on variability overlap layer of disposable diapers (Pham and Brown, 2009).

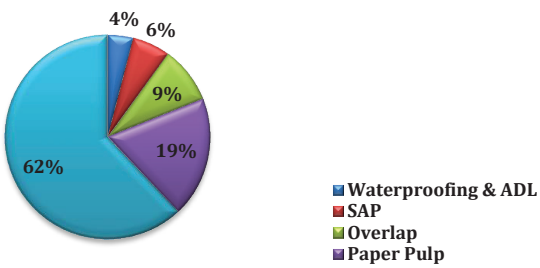

Figure 1. Breakdowns per diaper (by weight)

The addition of an electrolyte to the gel decreases osmotic pressure causing release of water from the polymer. For instance, sprinkling table salt (sodium chloride) on top of the gel will increase the electrolyte concentration outside the polymer and the gel will appear to "melt" as the water is released. Polyacrylate is an example of a super-absorbing polymer. It is a cross-linked (network) polymer that contains sodium atoms. It absorbs water by a process called osmosis. When the (sodium-containing) polymer is placed in contact with water, there is a tendency for the sodium to distribute equally between the network and the water. That means, some of the sodium atoms want to leave the network and move to the water. When these sodium atoms leave, they are replaced with water molecules. The water swells the polymer network to try to keep the sodium concentration balanced between the polymer and the water. The cross-links that connect the chains together to prevent them from dissolving or breaking apart in the water (Shooshitarian S., 2012).

Sodium Polyacrylate, also known as water lock, is a sodium salt of polyacrylic acid with the chemical formula [-CH2-CH(COONa)-] and broad application in consumer products. It has the ability to absorb as much as 200 to 300 times its mass in water. Sodium Polyacrylate is anionic polyelectrolytes with negatively charged carboxylic groups in the main chain. While sodium neutralized polyacrylic acids are the most common form used in industry, there are also other salts available including potassium, lithium and ammonium. These materials are made up from potassium Polyacrylate and polyacrylamide copolymers and are capable of quickly absorbing water after contact with it and holding it up to many times of its volume and as the result increase water retention in the related soil (Barihi et al., 2013).

Super absorbent polymers made from Polyacrylamide and these materials are used as water adsorbents to increase capacity of the soil to absorb and retain water. This property is very important to encounter the impacts of dehydration and reduce impacts of drought stress in crops. As an addition, the biodegradation rate of super absorbent polymers in the soil depends on the dimensions of soil particle and the amount of organic matter used. When the amounts of oxygen in the soil are decreasing, it will easily cause the reducing activities of bacteria and cause the biodegradation rate of super absorbent polymers will be reduced. Super absorbent polymers have an influence on the water infiltration rate in soil, bulk density, soil structure and the rate of evaporation from the soil surface.

2.3 Flowering Plants

The benefits of planting flowers include increased landscaping appeal and interest, enhanced emotional well-being, exercise for the gardener and environmental benefits. As an additional, according to Project Green, plants help to remove pollutants from the air. During the process of photosynthesis, the flower's leaves absorb carbon dioxide and release oxygen. As an addition, planting flowers also can help to hold soil in its proper plane, reducing erosion and flooding.

Figure 2. Yellow bell (Tecoma Stans)

Tecoma Stans flowers and bark are used for treatments of various cancers. This plant is a shrub or small tree, 5-7.6 m in height. The bark is pale brown to gray and roughens with age, while the leaves are compound with 2 to 5 pairs of leaflets and a larger single terminal leaflet. Leaflets are lanceolate, up to 10 cm long, with serrated margins, mid-green above and soft to the touch. Flowers occur in clusters at the ends of the branches and are trumpet shaped with 5 rounded lobes, 6 cm long, pale bright yellow, with faint orange stripes at the throat (Thirumal et al., 2012).

2.4 Growth Parameter

The roots have a type of cell called a root hair cell. Roots have a big surface area and thin walls, which allow water to pass into them easily. If the soils around the yard, landscape, or gardens have never been amended for plant growth, it may lack the three necessary nutrients such as nitrogen, phosphorus, and potassium. The growth index can be used as quantitative indicators of plant growth rate and to compare the size of the plants under different system. (Irman et al., 2004).

There are four parameters that we had been set up to ensure the plants are continuous growth in different composition of soil media, which is had been

filled up with super absorbent polymer. The parameters are height of plant, diameter of stem, the number of flowers and number of leaves (Dohuky, 2011).

2.5 Soil Stabilizer

The material is used to make up the soil to adopt in a state of high fertility suitable for tree planting. The Cocoa peat makes an excellent growing medium for hydroponics, soil mixes, and container plant growing. Coco peat is considered as a good growing media component with acceptable pH, electrical conductivity and other chemical attributes, but it has been recognized to have high water holding capacity which causes poor air-water relationship, leading to low aeration within the medium, thus affecting the oxygen diffusion to the roots (Awang et al., 2009).

Rice husk ash was more effective than activated carbon when the ash is used to bleach palm oil, but it will become less effective when it is used to bleach coconut oil and sesame oil. Rice husk ash contains over 90% silica and can be an economically viable raw material for the production of silicates and silica. It has unique properties which makes it a valuable raw material with many uses (Balakrishnan, 2006). In soil, rice husk works by improving the physical structure, chemical and biological soil. Husk could increase the porosity of the soil so that the soil becomes loose at the same time also increases the soil's ability to absorb water. Biologically, loose soil is a good medium for the growth and development of living organisms, either in the form of microorganisms, such as bacteria microorganism roots and the earthworms. Besides, the husk does not carry pathogenic microorganisms because the manufacturing process is through burning so relatively sterile (Ghassan, 2010).

Laterites are soil types rich in iron and aluminums, formed in hot and wet tropical areas. Laterites soil is also known as top soil, organic soil which is consists of organic materials and is usually not more than 500mm depth. This type of soil is normally disposed before a construction project is allowed in its. However, organic soils are useful for agriculture for any planting of trees. Nearly all laterites are rusty-red because of iron oxides. It has the highest concentration of organic matter and microorganisms and is where most of the Earth's biological soil activity occurs. The organic matter gives the its characteristic dark color while enhancing desirable physical properties such as tilts (ease of tillage), structure, water infiltration, and water-holding capacity (Koenig & Isaman, 2010).

3.0 METHODOLOGY

This project is an on-site research. Experiments were carried out to determine an optimum composition of SAP as soil catalyst. Specimens with the different percentage composition of soil and SAP were prepared as shown in Table 1. The study was conducted at the Taman Herba Politeknik Sultan Idris Shah, Sabak Bernam, Selangor which is located at an altitude of 6 meters above sea level and at a longitude of 100.876 and latitude of 3.826. The soils comprise a complex of somewhat excessively drained, shallow, stony and rocky soils of varying color, consistency and texture (dystric regosols with ferralic cambisols, lithic phase and rock outcrops).

The soils are acidic with high extractable Ca and K contents. Soil organic carbon and phosphorus content are 1.8% and 4 mg/kg, respectively. The pH of the soil ranges between 4.5 and 5.4. The soils have a water holding capacity of 40 percent. The area receives a fairly well distributed annual rainfall of 2130 mm. The studies were conducted in a plastic greenhouse measuring 20 m by 10 m in length and width and 7 m in height. The maximum and minimum temperatures in the structure were 24±2oC and 30±20C, respectively, with a relative humidity of 77±5%.

Table 1: Composition of SAP in NHRN samples

Sample	Soil (%)	SAP (%)	Water (ml)	Food (g)
NHRN 1	100	0	100ml	10
NHRN 2	90	10	100ml	10
NHRN 3	85	15	100ml	10
NHRN 4	80	20	100ml	10
NHRN 5	75	25	100ml	10
NHRN 6	70	30	100ml	10

The study was carried out for a period of 11 weeks, after which the seedlings were ready for grafting. The studies were conducted between Feb 2015 and April 2015. The morphological parameters determined were the number of leaves; plant height, stem diameter and number of flowers. The physiological parameters which are not determined were CO2 assimilation rate, transpiration rate, stomatal conductance, substomatal CO2 concentration and soil respiration. Plant height was measured from the base of the stem to the shoot apex using a meter ruler every week. All the fully expanded leaves, on each of the Tacoma Stans seedlings were counted and recorded every day to determine the number

of leaves. The diameter of each seedling was measured by a veneer caliper at a distance of 10 cm from the base of the stem every week at a resolution of 1cm to 100 cm. Each sample is given food, water and the same lighting due to its quantity and quality. The initial readings, before and after of plant growth are recorded and the percentage of decreasing and increasing of plant growth parameter are determined individually for every week.

4.0 RESULTS AND DISCUSSION

4.1 Diameter of Stem

The difference in total increment of diameter stem between initial to final are in the range of 0.9 – 2.5 cm for all samples which contribute 46.67 – 164.29 % in 11 weeks duration. Despite being an initial smallest stem diameter (1.4 cm), samples NHRN 5 showed total percentage increments of 164.29% compared to control sample NHRN 1 which is 46.67% only. NHRN 5 shows the highest total percentage increments among all samples as shown in Figure 3.

Keshavarz and Farahbakhsh (2012) evaluated the effects of Superabsorbent and drought stress on yield components of forage millet. The results showed that adding of Superabsorbent could increase dry and fresh weights, height and diameter of the stem, node and claw number of forage millet.

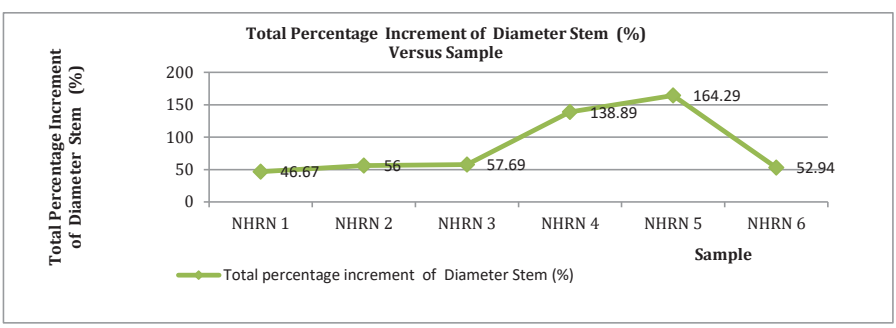

Figure 3. Total percentage increment of diameter stem

4.2 Height of Plant

The total increase in height of the sample 1, 2, 3, 4 and 6 were in the range of 18 – 33.5 cm except for samples NHRN 5 which shows an increase of maximum height of 33.5cm. Figure 4 shows the optimum total percentage increments of

height for sample NHRN 5 was 88.86%, nevertheless, the NHRN 1 (control sample) increases at the minimum height of growth by 39.56%.

Zangooei-Nasab et al. (2012b) evaluated the effects of SAP and irrigation period on some physical characteristics of soil and growth indices of Atriplex plant. The results showed that SAP had a significant effect (at the 5% level) on some growth indices, including plant height, dry and fresh weight of aerial organs, dry and fresh weight of roots and root length.

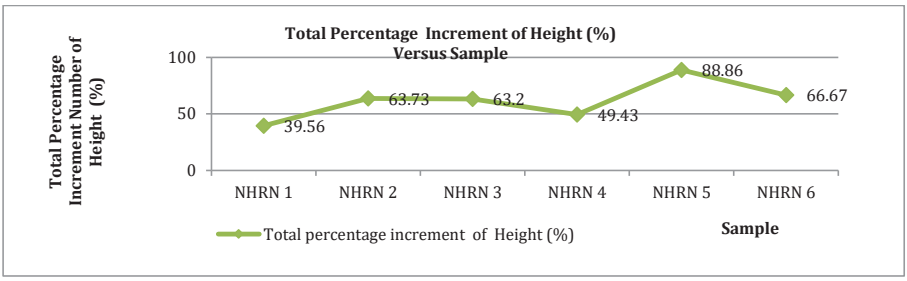

Figure 4. Total percentage increment of height

4.3 Number of Flower

All samples have increased between 21 - 94 buds. Figure 5 shows the sample of NHRN 5 increase the maximum total percentage increment number of flowers by 9400% compared to the control sample NHRN 1 with minimum of 2100%. Islam et al. (2011) evaluated a water saving SAP (Granular type) for minimizing NO3− leaching from soil and optimizing corn growth and yield. The application of SAP increased yield significantly by 44.4% on level-1 and 80.3% on level-2, respectively.

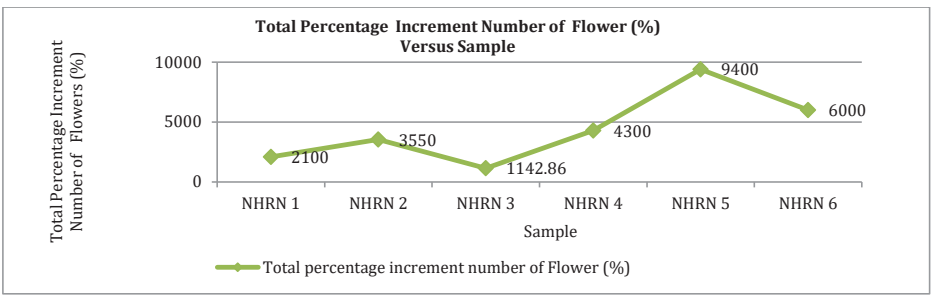

Figure 5. Total increment number of flower

4.5 Number of Leaves

Total increment number of leaves for all NHRN samples are below 400 pieces compared to NHRN 5 which reach to 461 pieces (517.98%) as shown in figure 6. However, NHRN 1 (control sample) shows the lowest number of increments of 185 pieces (154.17%).

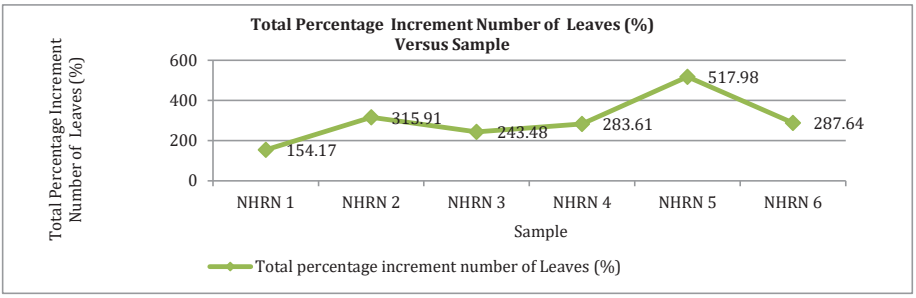

Figure 6. Total increment number of leaves

5.0 CONCLUSION

In conclusion, the objectives are achieved. SAPS were added to the composition of soil, and catalyst for the soil was produced. Recycling these SAPS can reduce the landfill burden and leachate production and this is benefit to the environment and sustainable development. An optimum sample was chosen by comparing all the morphological parameters in SAP sample. This project will help to reduce and minimize the generation of leachate and disposal diapers into most productive ways.

In this project, the desired growth parameter for Tacoma Stans are high in total increment of diameter stem, high increment of height, high total increment number of flower and leaves. As a result, Sample NHRN 5 is chosen as the optimum compositions of landscape catalyst, with the composition of 75% soil and 25 % SAP. This is because Sample NHRN 5 has the highest percentage in morphological parameters among other samples.

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