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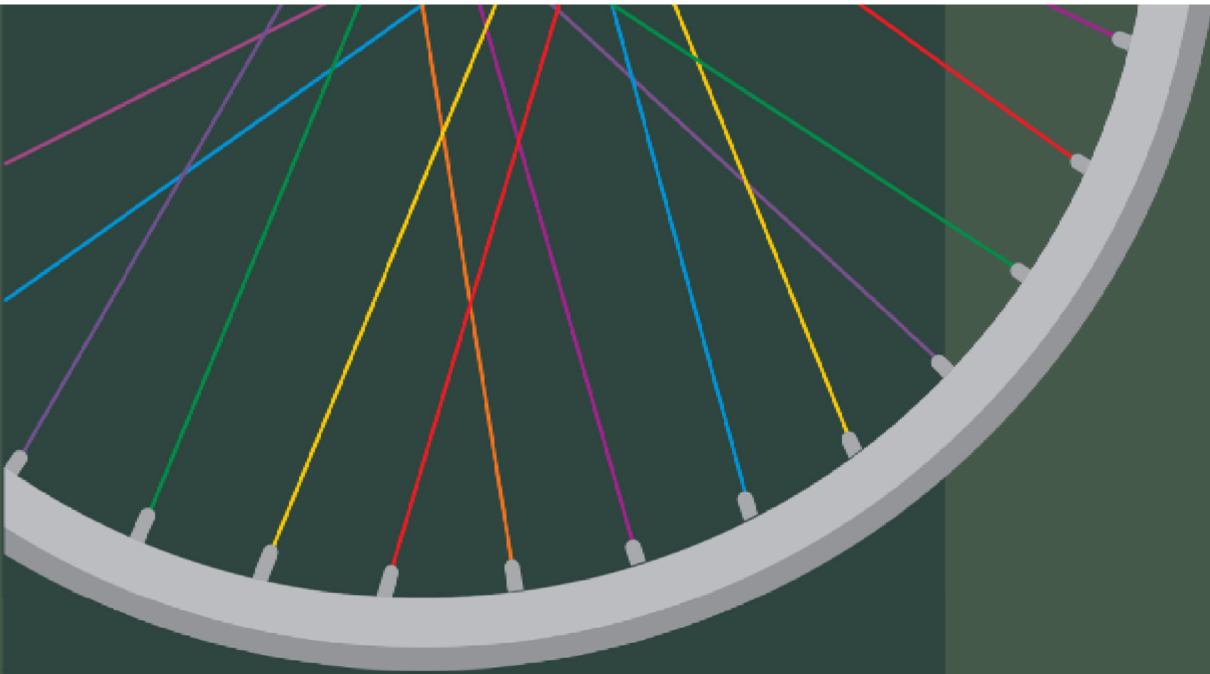

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19.SUSTAINABLE USE OF DISPOSABLE DIAPER (SAP) IN AGRICULTURAL PRACTICES – A STUDY BASED ON *Capsicum annum* PLANT

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ABSTRACT

Disposable diapers create a huge waste problem globally because of its nonbiodegradability of the plastic lining and Super Absorbent Polymer (SAP). Previous studies showed that people used the diaper gel (SAP) for smallscale cultivation including in Kerala because of its water absorbing capacity. The public adopts such methods as a sustainable method for the processing of waste diapers. There is no scientific study is available for the toxic effect of SAP gel and the chemicals derived from it on the plant growth so far. Acrylic acid derived from SAP were reported as low toxic to animals and detrimentally affects seed germination, but its phytotoxicity were not studied yet. Therefore, the study focused on the changes in the chemical and physical structure of the soil due to the use of disposable diaper SAP, the effect on plant growth and the changes in plant nutrients and plant heavy metal concentration. The Capsicum annuum (Green chilli) plants, which is widely grown in the climate of Kerala and is mainly cultivated in the kitchen gardens here, was used for the study. The plants were grown in normal soils and SAP added soils to find out the differences. Water absorption capacity and nutrients like phosphorus, nitrogen, zinc, copper and sodium were found to be high in SAP soils. The study also shows that when SAP is 5 percentage, the plants show a higher growth rate. The study suggests that this method cannot be said to be completely sustainable as the plants show stunted growth when high doses of SAP are used and the presence of heavy metals in soil and water also causes heavy metal accumulation in plants which are grown in SAP containing soils.

Keywords: Nonbiodegradability, Disposable diaper, Diaper gel, Phytotoxicity

1.INTRODUCTION

Disposable diapers are widely used in this modern age and create a huge waste problem globally because of its nonbiodegradability of the plastic lining (polythelene film) and

Super Absorbent Polymer (SAP-Sodium polyacrylate) (Meseldzija *et.al* 2013). The reason it is used as the main raw material for disposable diapers is that the SAP, which is composed of sodium polyacrylate molecules (Ajmi *et.al* 2020), can absorb and retain water up to 100 times of its weight (Kumar et.al 2018). The sodium polyacrylate mentioned above is formed by the polymerization of sodium acrylate monomers and acrylic acid monomers. In some cases, the SAP was associated with showing toxic shock syndrome and causing skin irritation in children (Laylin 2015, Aishwariya and Priyanka 2020). Disposable diapers that are discarded after use have also been found to be a source of infection (Meseldzija *et.al* 2013). The reality is that with all of this, disposable diapers are becoming a public health threat.

In addition, disposable diapers, which cause many other environmental problems, are the third largest individual constituent of solid waste in municipal waste (Khoo *et.al* 2019). Traditional methods such as incineration, landfill and many other recent techniques are used for their processing. Conventional treatement methods pose an environmental challenge because they are non-biodegradable in the soil and emit toxic gases including Dioxin during combustion (Khoo et.al 2019).

Many countries have already developed a variety of modern processing technologies and reusable possibilities to overcome the environmental challenges posed by traditional processing methods for disposable diaper waste. So most recently introduced technologies for the treatment and recycling of disposable diapers are thermal method by the pyrolysis of diapers in which the diaper degraded in an inert environment and hence limits the production of greenhouse gases (Khoo et al. 2019), hydrothermal carbonization (Budyk and Fullana 2019), biodegradation of diaper polymer by bacteria (*Bacillus*, *Psueodomonas*), fungi (*Aspergillum*, *Pencillium*) and mushroom *Pleurotus* sp. (Khoo et al. 2019). Recently microbial enzymes convert the cellulosic material of diaper into soil fertilizer and garden compost were also reported. The use of shredded waste of disposable diapers for concreting purpose is an example of the reusability that has recently been developed. Even though all these methods are eco-friendly, it is highly expensive and time consuming.

It has been noticed that many people in kerala use diaper gel (SAP) for small scale/kitchen garden cultivation after use as an effective/sustainable processing method of disposable diapers and spread such non-authentic ideas through social media like youtube(https://youtu.be/7fSQNMPvGdo,https://youtu.be/dn_oG2NU_Xg, https://youtu.be/B7DNugiDN6g, https://youtu.be/bj4YHzsDMCg). Based on studies that have shown that the gel inside the disposable diaper (SAP) absorbs more water and helps to accelerate plant growth by increasing soil moisture content (Kumar et.al 2018), it is less expensive and more attractive to the public than other treatment methods. It is found that the people directly applying the SAP to the plants without adding any other enhancers so there is no possibility to release water to soil. This will lead to the detention of water within the SAP and it may also cause the soil to become dry.

Although super absorbent polymer is used in agriculture, it is chemically Potassium polyacrylates and the potassium contained in it helps to accelerate plant growth. On the other hand, the SAP contained in disposable diapers is sodium polyacrylate and which is useless to plants and causes soil hardness(https://absorbantmaterial.net/sodium-polyacrylate-for-your-plants-its-time-to-stop/). In addition sodium, acrylicacid, fragrant chemicals and germs that come out of diaper gel can significantly affect plant growth and morphology (Chen et.al 2016). The lack of authoritative scientific study reports on the use of diaper gel in the agricultural sector of the above type is a matter of serious concern and needs to be studied. Therefore, this study based on this relevant topic will help to suggest a sustainable approach to disposable diaper waste treatment and to expand public health care. So the study focused on the changes in the chemical and physical structure of the soil due to the use of disposable diaper SAP, the effect on plant growth and the changes in plant nutrients and plant heavy metal concentration.

2. MATERIALS AND METHODS

2.1. Selection of plants and soil

One to two week old seedlings of *Capsicum annuum* (Green chilli) plant, which is growing with a short duration (approximately 2 months) and widely cultivated in Kerala climate, was used for the study. The soil for the study was collected from my backyard in Pang area of Perinthalmanna taluk in Malappuram district.

2.2. Methodology

Used disposable diapers (urinated only) collected from near the house, the SAP was extracted, cut into small pieces and mixed well to get uniform urine concentration. 7 growbags set up and filled with 5kg soil in each, collected from the same place in the backyard. Added 1% SAP (50g) in one bag, 5% SAP (250g) in another and 10% SAP (500g) in the next and mixed well with the soil to get uniform SAP concentration. Quality seedlings were planted in one each. Plants in the remaining three bags were allowed to grow naturally without adding SAP and the soil in the seventh bag was set as control.

The plants labeled as,

CN - Capsicum annuum Normal

C-1% - Capsicum annuum+1% SAP

C-5% - Capsicum annuum+5% SAP

C-10% - Capsicum annuum+10%SAP.

Twice daily, 150 ml of water was used for irrigation of each plant and every two days the growth of the plants and the number of leaves were recorded.

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2.2.1. Sample collection

250g of soil was collected from each bag at 20 day intervals (on 20th day, 40th day and 60th day) and stored for analysis. The leaves collected for analysis on 60th day.

2.2.2. Soil analysis

The collected soil samples were dried in the shade and sieved through a 2mm sieve and tested for the following parameters.

a)P^H

10g of soil was mixed with 25ml of distilled water and shaken for 30 minutes on a shaker. The P^H value was recorded using a caliberated P^H meter.

b) Soil texture

50ml of Hydrogen peroxide (6%) added to 50g of soil and put in hot water bath for 30 minutes. Added 100ml of Sodium hexa metaphosphate and stirred for 5 minutes. Then it is transfered in to 1000 ml measuring cylinder, made up to 1000 ml and stirred well. Readings were recorded with a hydrometer for 4 minute and 2 hours without stirring.

$$\text{Clay\%} = \frac{3.08(\text{corrected reading}) + @2\text{hrs}*100}{\text{Weight of soil}}$$

$$\text{Silt\%} = \frac{(3.08+@4\text{min}-(3.08+@2\text{hrs})*100)}{\text{Weight of soil}}$$

$$\text{Sand\%} = 100-\text{Clay}+\text{Silt}$$

c)Organic carbon

5ml of 1N Potassium dichromate and 10 ml of concentrated sulphuric acid were added respectively to 0.5g of soil(sieved in 0.5mm sieve) taken in conical flask. After 30 minutes,added 20ml of distilled water and 3-4 drops of O-phenophthaline indicator. Titrated against FAS and end point recorded when yellow colour of the solution became green colour.

$$\text{Organic carbon\%} = \frac{\text{Titre value*FAS normality*0.003*100}}{\text{Weight of soil}}$$

d)Water absorption capacity

Place the filter paper inside the funnel above the conical flask and added 25g of soil in to it. Pour 100ml of water and after 10 minutes record the amount of water that has settled in the bottom of conical flask.

Water absorption capacity(%)=100-volume of water settled in the bottom flask

e)Micronutrients and heavy metals

Acidic soil – 20ml of 0.1 N HCL added to 2g of soil and shaked for 5 minutes. Filtered through a filter paper and the extract was used for the reading in a caliberated Atomic Absorption Spectrometer(AAS).

Alkaline soil – 20ml of DTPA added to 2g of soil, shaked for 2 hours and the extract was used for the reading in AAS.

Micronutrients/Heavy metals(ppm) = AAS reading*20/2

f)Macronutrients

f.1)Nitrogen

Added 5g soil to nitrogen tube, 20ml boric acid to conical flask and placed both of these in nitrogen device for 8 minutes. The resulting solution in the conical flask titrated against 0.02N H_2SO_4 and the end point detected when the colour of the solutions turned blue to wine red.

$$\text{Nitrogen(ppm)} = \frac{\text{Titre value}*H_2SO_4\text{ normality}*0.014*10^6}{\text{Weight of soil}}$$

f.2)Phosphorous

25ml of Bray no.1 solution added to 2.5g of soil,shaked well for 5 minutes and the extract collected using filter paper. 5ml of this extract transfered in to 25ml standard flask, added 4ml of Ammonium paramolybdate in to it and made up to 25 ml with distilled water. Shaked well and estimated phosphorous in a caliberated spectrophotometer after 30 minutes.

Phosphorous(ppm)=SPEC reading*25/2.5*25/5

f.3)Sodium, Potassium, Magnesium

25ml of Neutral Ammonium acetate added to 5g of soil, shaked well for 5 minutes and filtered through a filter paper. This extract used for the estimation of Sodium and Potassium with flamephotometer and Magnesium with Atomic Absorption Spectrometer.

Sodium/Potassium/Magnesium(ppm) = Reading*25/5

2.2.3.Leaf sample analysis

A pinch of Salicilic acid powder, 10ml of con.H_2SO_4 and 10ml of 30% Hydrogen peroxide were added to 0.2g of dried leaf sample in digestion tube. Placed for 2 hours in digestion tube, digested solution made up to 100ml in standard flask and used for further analyses.

a)Nitrogen

Added 10ml of the above solution in to nitrogen tube, 20ml boric acid to conical flask and placed both of these in nitrogen device for 8 minutes. The resulting solution in the conical flask titrated against 0.02N H_2SO_4 and the end point detected when the colour of the solutions turned blue to wine red.

$$\text{Total Nitrogen} = \frac{\text{titre value* } H_2SO_4 \text{ normality*0.014*100}}{\text{Sample weight*volume of the solution}}$$

b)Phosphorous

4ml of Ammonium paramolybdate added to 5 ml of the solution and estimated phosphorous with Spectrophotometer after 30 minutes.

Total phosphorous = SPEC reading *100/sample weight *25/5

c)Potassium, Sodium

Solution estimated with Flamephotometer.

Total potassium/Total Sodium = Photometer reading *100/sample weight

d)Magnesium,Heavy metals, Micronutrients

Solution estimated with Atomic Absorption Spectrometer.

Total Magnesium/Heavy metals/Micronutrients = AAS reading *100/sample weight

2.2.4.Estimation of plant growth rate

The length from the base to the top of the plant was measured with a tape and repeated for every 2 to 3 days.

Growth rate = $(S_2-S_1) / T_1$ where, S_1=first measurement
S_2=second measurement
T=number of days between each.

Triplicated measurements and analysis conducted to ensure the fidelity of the experiments.

3. RESULTS AND DISCUSSIONS

The major results of the study are given below:-

3.1.Texture of soil

The texture of the soil varies according to the amount of clay, sand and silt(Table 1).Control and four other types of soil(CN,C-1%,C-5%,C-10%) have a sandy clay loam texture(containing about 70% sand). Unlike the control, all four types of soils show a slight decrease in the amount of sand(control-73.84%, others - <73.84%) and an increase in the amount of clay(control – 20.16%, others - >20.16%). CN and C-5% show less amount of sand(6% less than control) and higher percentage of clay than the control(6% higher than control).

Sand percentage decreases as a result of the decay process that plant root take in the soil in which they grow. Clay levels inncrease due to the presence of water and rotten leaves in the soil where the plants grow(https://www.pennington.com/all-products/fertilizer/resources/how-to-improve-heavy-clay-soil).

Table 1. Texture of soil

		Clay	Silt	Sand
	Control	20.16	6	73.84
S.GC	CN	26.16	6	67.84
	C-1%	24.16	6	69.84
	C-5%	26.16	6	67.84
	C-10%	22.16	6	71.84

3.2.Water absorption capacity

All four types of soils show water absorption capacity higher than the control(17%). As the amount of SAP increases, the absorption capacity of soil increases(Fig1). 10% SAP containing soil shows higher water absorption capacity(25%).CN and C-1% show absorption capacity close to the control(18%).

While SAP can absorb water up to a hundred times of its weight, the soil with high amount of SAP shows higher water absorption capacity(Ajmi et.al 2020, Kumar et.al 2018).

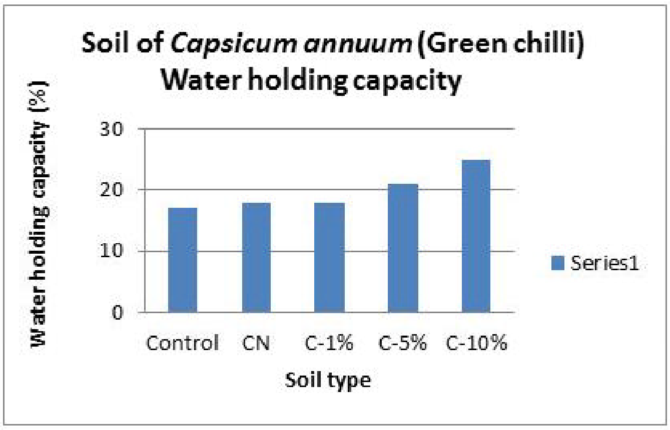

Figure 1. Water absorption capacity of soil

3.3.P^{H}

All types of soils, including control show P^{H} value very close to neutral P^{H}(6.62-7.3). Even though control has a slightly higher P^{H} value(7.16). The lowest P^{H} is in CN(6.7) and highest is in C-10%(7)(Table 2).

Decreased levels of nutrients in the soil in which the plants grow cause the P^{H} value to decrease(Soil Quality Kit – Guides for educators, USDA-NRCS). SAP shows P^{H} neutrality when it absorbs water and so C-10% which contains more SAP shows P^{H} neutrality(Kumar et.al 2018).

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Table 2. P^H of soils

	Control	7.16	7.16	7.16
S.GC	CN	6.7	6.53	6.76
	C-1%	6.78	6.98	6.54
	C-5%	6.99	6.84	6.82
	C-10%	6.83	7	6.73

3.4.Organic carbon

All types of soil except C-10% show organic carbon percentage lower than that of control(Fig 2). C-10% has a carbon value of 2.04% which is 0.13% higher than that of control carbon value(1.91%). C-5% has the lowest organic carbon percentage(1.48%).

Absorption of organic carbon in plant growing soils results in lower organic carbon value than control. Studies on the use of urine-containing baby diapers for composting have shown that these diapers contain 89% of organic carbon(Navarro et.al 2014). Therefore, more SAP containing C-10% has high levels organic carbon even after vegetative absorption.

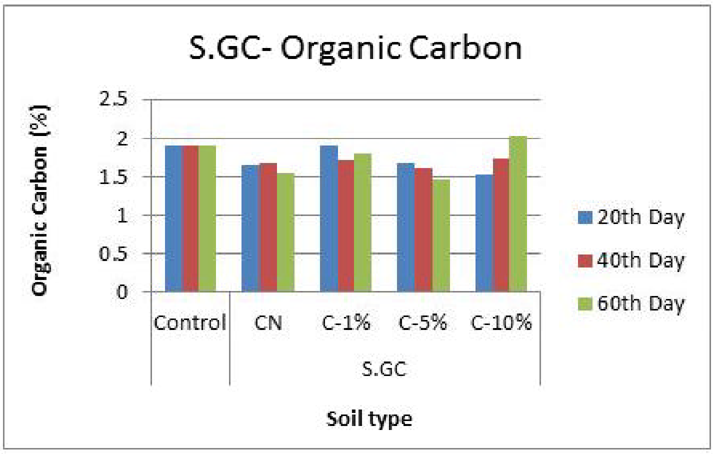

Fig 2. Organic Carbon in soil

3.5.Macronutrients

Nutrients that are required in large quantities are known as macronutrients. Nitrogen, phosphorous, potassium and magnesium are the major macronutrients.

Nitrogen

Plants growing soils have higher nitrogen value than the control(50.4 ppm)(Fig 3). Higher nitrogen value can be seen in C-5%(72.8 ppm).

Decay of plant wastes in the soil in which the plants grow and accumulation of urine and other materials in the soil in which the diapers were added caused the nitrogen value to be higher than the control(Espinosa et.al 2014).

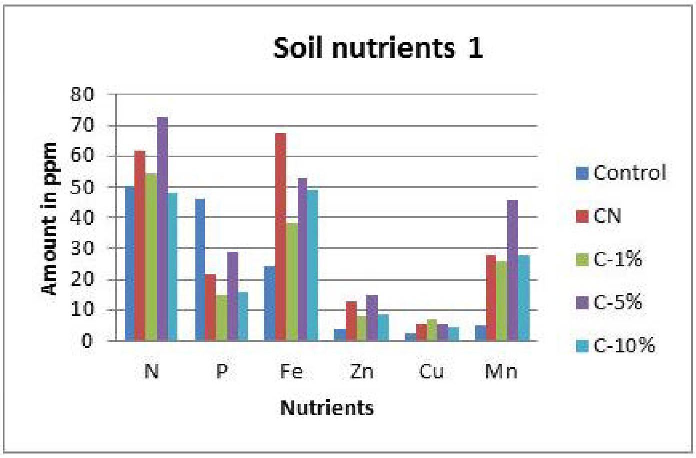

Fig 3.Soil nutrients 1

Phosphorous

Control has the highest phosphorous value(46.1 ppm) and lower phosphorous values can be seen in plant growing soils(Fig 3). Excluding control, the phosphorous content in other soil types is more in C-5%(28.76 ppm) and less in C-1%(14.77 ppm).

As phosphorous is a macronutrient, it is absorbed by plants,which reduces the value of phosphorous in the soil where the plants grow. Phosphorous comes out of the urine in the diaper increases the phosphorous value in C-5%(https://www.earthmagazine.org/article/p-phosphate-could-urine-solve-fertilizer-shortage).

Potassium

Control has higher potassium value(825 ppm) and C-1% has the lowest(425 ppm). Potassium content is less in soils in which plants are grown(Fig 4).

As potassium is a macronutrient, it is absorbed by plants, which reduces the value of phosphorous in the soil where the plants grow.

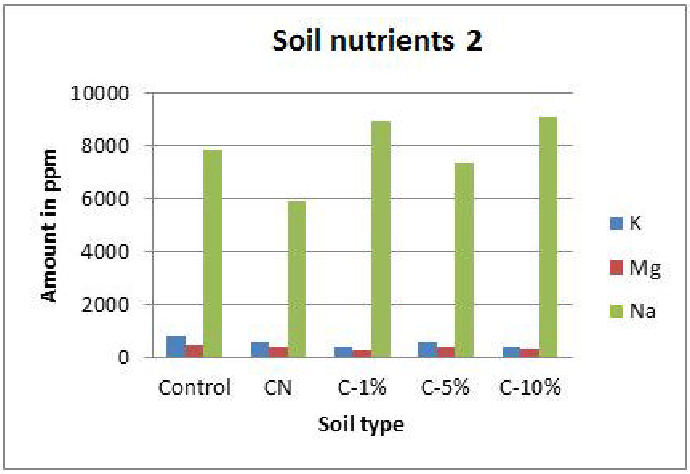

Fig 4. Soil nutrients 2

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Magnesium

Control has the highest content of magnesium(472.446 ppm) than the soils in which the plants grow(Fig 4). The control differs by about 100 ppm from other types. The lowest magnesium content is in C-1%(248.937 ppm).

As Magnesium is a macronutrient, it is absorbed by plants, which reduces the value of magnesium in the soil where the plants grow.

3.6.Micronutrients

Nutrients that are required in less quantities are known as micronutrients.

Iron

All four types of soils show higher iron content than the control(24.38 ppm)(Fig 3). It shows highest value in CN(67.5 ppm).

In other soil types that have a lower P^H than the control, the P^H variation increases the iron content(https://plantprobs.net/plant/nutrientlmbalance/iron.html).

Zinc

Control has the lowest zinc content(4.009 ppm)(Fig 3). Other four types have increased zinc content than control and the highest value is in C-5%(14.749 ppm).

Previous study had suggested that zinc contained in disposable diapers and they may increase the amount of zinc content in the soil(Colon et.al 2010).

Copper

All four types of soils show higher copper content than the control(2.45 ppm)(Fig 3). Copper more in C-1%(7.12 ppm).

Diaper SAP containing soil absorbs more copper and so copper is more abundant in SAP mixed soils(De varennes A).

Manganese

Manganese content is lowest in control(5.09 ppm) and highest in C-5%(45.44 ppm)(Fig 3). In plant growing soils, the amount of manganese is found to be higher than the control. The low P^H value of the soils lead to an increase in manganese levels in the plant growing soils(https://www.google.com/url/?sa=t&source=wed&rct=j&url=http://corn.agronomy.wisc.edu/management/pdfs/a2526.pdf&ved=2ahUKEwibut2P6aL2AhXPS2wGHVBmB68QFnoECCwQBg&usg=AOvVaw0bFpX7RPUfcn17e5F-2CDo).

Sodium

SAP containing soils have increased amount of sodium than the control soil(7887.5 ppm)(Fig 4). Highest value is in C-10%(9137.5 ppm) which is 0.125 % higher than that of control.

Sodium contained within the diaper SAP leads to an increase of sodium in SAP containing soils.

3.7.Heavy metals

Heavy metals are metallic chemical element that have a relatively high density and are toxic even at low concentrations.

Cadmium

All types of soils including control show cadmium value zero or close to zero(Fig 5). It indicates that the use of diaper SAP do not affect the value of cadmium in the soil.

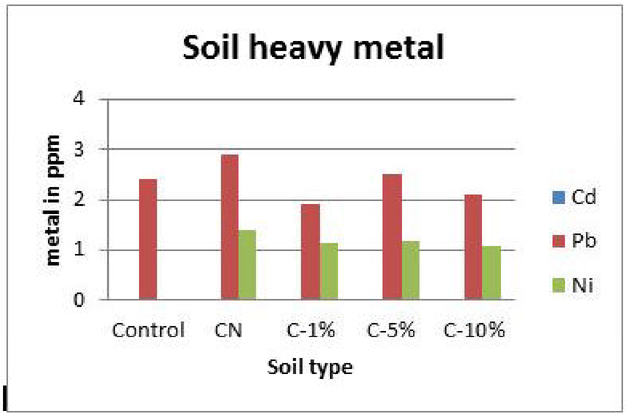

Fig 5. Soil heavy metal

Lead

Control has a lead content of 2.4 ppm.There is no significant changes in lead content of other soils from control(Fig 5). Relatively high content is in CN(2.9 ppm) and low content is in C-1%(1.9 ppm). It indicates that the use of diaper SAP do not affect the value of lead in the soil.

Nickel

Plant growing soils show increase of nickel content from control(0.03 ppm)(Fig 5). Highest value of nickel is in CN(1.38 ppm).

Low P^{H} increases the availability of nickel in the soils in which the plants grow (https://edis.ifas.ufl.edu/publication/HS1191).

3.8.Macronutrients in plant material

Nitrogen

Plants grown in naturally set up soil without SAP(CN) have relatively less nitrogen(2.38 ppm) than those used SAP(Fig 6). Lowest nitrogen value is in C-10%(1.4 ppm) and highest is in C-1%(3.08 ppm).

Plants show changes in nitrogen content according to the availability of nitrogen from their growing soil.

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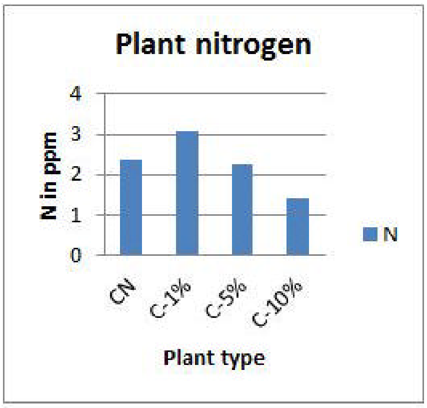

Fig 6. Plant nitrogen

Phosphorous

The phosphorous content of SAP used plants are higher than that of CN(926 ppm)(Fig 7). Phosphorous content in the plant material increases with the increase of SAP content in the soil,thus C-10% has the highest phosphorous value(1148.25 ppm).

Phosphorous from the urine containing SAP increases the presence of phosphorous in the soil and thus plants grown in that soils(https://www.earthmagazine.org/article/p-phosphate-could-urine-solve-fertilizer-shortage)

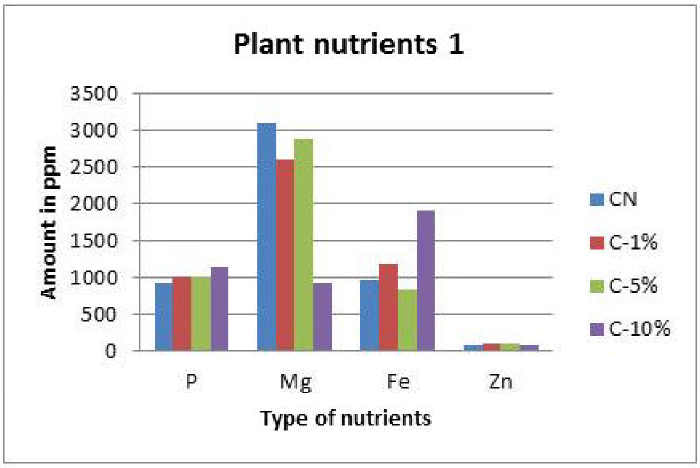

Fig 7. Plant nutrients 1

Potassium

C-1%(31250 ppm) has the lowest potassium content and C-5% has the highest(38650 ppm)(Fig 8).

SAP can absorb more water that contains potassium and this leads to the increase of potassium content in the corresponding plants.

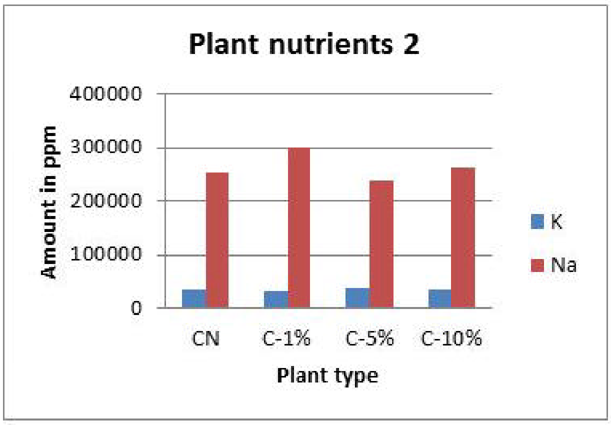

Fig 8. Plant nutrients 2

Magnesium

Higher amount of magnesium can be seen in CN plant(3105 ppm) and plants grown in SAP containing soils show low magnesium values than CN. C-10% has the lowest magnesium content(935 ppm)(Fig 7).

Lowest chlorophyll content leads to lowest magnesium content in SAP containing soils.

3.9.Micronutrients in plant material

Iron

The iron content of SAP used plants are relatively higher than that of CN(966.5 ppm). The highest value is in C-10%(1913 ppm)(Fig 7).

The SAP with higher water absorption capacity absorbs more water from the soil and as a result iron gets absorbed by SAP in larger quantities. Plants growing in SAP containing soils absorb large amounts of iron from these SAP and it resulted in increase in the iron content of such plants(Kumar et.al 2018).

Zinc

The zinc content of SAP used plants are higher than that of CN(81.85 ppm)(Fig 7). Highest amount of zinc can be seen in C-5%(99.8 ppm).

Previous study had suggested that zinc contained in disposable diapers and they may increase the amount of zinc content in the soil(Colon et.al 2010). As a result plants grown in these soils absorb more zinc from the SAP and show higher zinc value in their leaves.

Sodium

C-1% (300000 ppm)has the highest sodium content and C-5% has the lowest(237500 ppm)(Fig 8).

Sodium content is relatively higher in SAP containing soils.

3.10.Heavy metals in plant material

Cadmium

C-10% shows lowest cadmium content(56 ppm) and C-1% shows highest cadmium content(72 ppm)(Fig 9).

The SAP with higher water absorption capacity absorbs more water from the soil and as a result cadmium gets absorbed by SAP in larger quantities. Plants growing in SAP containing soils absorb large amounts of cadmium from these SAP and it resulted in increase in the cadmium content of such plants(Kumar et.al 2018).

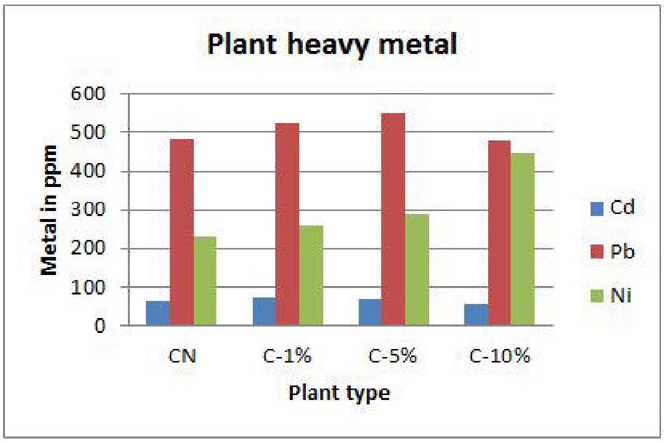

Fig 9. Plant heavy metal

Lead

C-10% shows lowest lead content(480 ppm) and C-5% shows highest lead content(550 ppm)(Fig 9).

The SAP with higher water absorption capacity absorbs more water from the soil and as a result lead gets absorbed by SAP in larger quantities. Plants growing in SAP containing soils absorb large amounts of lead from these SAP and it resulted in increase in the lead content of such plants(Kumar et.al 2018).

Nickel

CN shows the lowest nickel content(228.5 ppm) and nickel content of plants increase with the increase in SAP content of the soil in which they are grown(Fig 9). So C-10% has the highest nickel content(445.5 ppm).

The SAP with higher water absorption capacity absorbs more water from the soil and as a result nickel gets absorbed by SAP in larger quantities. Plants growing in SAP containing soils absorb large amounts of nickel from these SAP and it resulted in increase in the nickel content of such plants(Kumar et.al 2018).

3.11.Growth rate of plants

CN and C-1% have approximately the similar growth rate. C-10% has a stunted growth and C-5% shows higher growth rate(Fig 10).

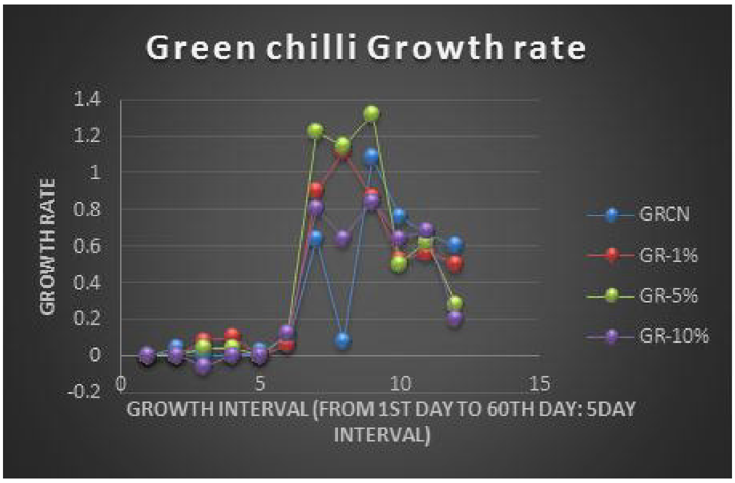

Fig 10. Plant growth rate

C-5% have higher growth rate and it indicates growth of the plant increases when the SAP is 5% of the soil.

4. CONCLUSION

Disposable diapers, which are widely used even in rural areas, are causing a huge waste problem today. Small scale agricultural use of disposable diaper SAP is a popular method of sustainable processing of disposable diaper waste in many parts of Kerala. This study was an attempt to find out how sustainable this method is. Therefore, the study focused on the changes in the chemical and physical structure of the soil due to the use of disposable diaper SAP, the effect on plant growth and the changes in plant nutrients and plant heavy metal concentration. Three different percentages of SAP were added to the soils to achieve these study objectives.

SAP added soils were found to have 5 to 8 percent higher water absorption capacity than normal soils. This is because SAP can absorb water up to 100 times of its weight. The finding that the macronutrients such as nitrogen and phosphorous, the micronutrients such as zinc and copper are more abundant in SAP containing soils indicate that they are mixed to the soil from SAP. Similarly, the sodium content of the SAP increases the sodium content of the soil. The use of SAP does not cause significant changes in the soil heavy metal content. Examination of the leaves of the plants revealed that phosphorous, nitrogen and sodium were higher and magnesium found to be low in plants which grown in SAP containing soils. The plants which grown in SAP containing soils show twice as much heavy metal than the corresponding soils. The SAP with higher water absorption capacity absorbs more water from the soil and as a result heavy metals gets absorbed and concentrated by SAP in larger quantities. Plants growing in SAP containing soils absorb large amounts of heavy metals from these SAP and it resulted in increase in the heavy metal content of such

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plants. It was found that 5% of SAP gives maximum growth rate. 1% SAP containing soil and normal soil have approximately the similar growth rate and 10% SAP has a stunted growth.

Excessive use of SAP causes stunted growth of plants and the presence of heavy metals in soil and water also causes heavy metal accumulation in plants which are grown in SAP containing soils. Therefore, the use of SAP in the production of edible vegetables cannot be said to be a sustainable method. This method can only be said to be sustainable if moderate levels of SAP are used and ensuring that no heavy metals present in the soil or water.

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