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A Study on the Fate of Expired Amoxicillin Antibiotic Tablet Disposal on Soil Environment

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Abstract

Among the various class of drugs, antibiotics are one such group of pharmaceuticals that has got greater usage in the current scenario. Improper disposal of various antibiotics has several negative impacts on the environment, public health, and the efficacy of waste management systems. Amoxicillin is one such class of compound used to treat bacterial infections such as chest infection and dental abscesses. It enters into the domestic environment by the disposal of various household wastes. Improperly disposed amoxicillin antibiotics in any environment has negative effect on the surrounding environment. Based on the above concept, the present study has been undertaken. The experimental setup includes a pilot study in order to know the frequently disposed expired amoxicillin tablets effect on the soil quality. For the study, expired Amoxicillin antibiotic was used. The organoleptic characterization and physical tests of expired amoxicillin tablet was conducted in order to study its various characteristics. During the present study, the expired amoxicillin tablets were powdered and added at a concentration of 1g, 5g, and 10g to the collected landfill soil sample and kept for observations for 30 days. The soil samples were collected and subjected to extraction and used for the analysis of various physico-chemical parameters. The percentage of friability of an expired tablet was 0.0065%. The disintegration of the amoxicillin was completed around 45minutes. The dissolution rate of expired amoxicillin was 0.45% at 120minutes.This indicates, it can dissolve quickly under various environmental conditions. From the study, it can be concluded that, the disintegration of expired amoxicillin tablets can alter the soil properties and reduce the soil quality.

Key Words: Antibiotic, Amoxicillin, Expired drug, Organoleptic properties, Soil Quality

I. Introduction:

Pharmaceutical wastes include a wide range of medicines that are used to treat different diseases. Antibiotics are one of the type of pharmaceuticals, that has seen increased in use. Antibiotics in the environment can promote the development of antibiotic-resistant bacteria, affect microbial communities, and disrupt ecological processes [1]. The presence of antibiotics like amoxicillin in pharmaceutical waste can contribute to environmental contamination and pose risks to ecosystems and human health. Amoxicillin is a broad-spectrum antibiotic commonly used to treat bacterial infections in humans and animals. Its primary purpose is to inhibit the growth of bacteria by interfering with their cell wall synthesis [2].When amoxicillin is excreted by the animals or disposed of improperly, it can leach into the soil. In soil, amoxicillin antibiotics can persist for longer periods, potentially affecting the microbial communities. Amoxicillin can adsorb to soil particles, which can reduce the mobility and increase its persistence in the soil. The extent of sorption depends on the factors like soil organic matter content, clay mineral composition and pH. Few researchers stated that, the amoxicillin can inhibit the growth of certain soil bacteria [3]. The presence of amoxicillin in soil can affect the soil microbial activity, nutrient cycling and soil structure. The changes in soil properties may reduce soil fertility and impair plant growth.

Amoxicillin can enter aquatic environments through several pathways, including runoff from agricultural areas, effluent, and improper disposal of unused medications. In water, antibiotics can persist and may have detrimental effects on aquatic organisms [4]. Manystudies have shown that, the amoxicillin can affect the growth, reproduction, and behaviour of various aquatic species, including fish, algae, and invertebrates. Additionally, there's a risk of promoting antibiotic resistance in bacteria present in aquatic and soil environment [5]. Based on the above concept, the present research work has been aimed to evaluate the impacts of expired amoxicillin antibiotic tablet on soil quality.

II. Materials and methodology:

A. Pharmaceutical Analysis

2.1 Organoleptic Characterization and physical test of expired amoxicillin tablet:

In the present study, in order to know the properties of the expired antibiotic drug, the general organoleptic properties were done. In order to ensure that the tablet comply with standard quality and are safe for use, the organoleptic characterization was carried out. This method consists of evaluating the sensory qualities, like appearance, odour, taste and texture.

To find any unique layers or coatings in the expired medication, the tablet wasexamined cross-sectionally. The average weight of the tablets was determined by weighing each one separately. The tablets were evaluated for the

overall appearance including any printing or embossing for clarity and uniformity. To determine the concentration or quantity of the active pharmaceutical component included in the tablets, the drug dosage and drug content were examined. The drug classifications are important inorder to protect from severe chronic effects and drug interactions. The therapeutic class of the tablets were examined through the label of the tablets.

The physical tests of expired amoxicillin tablets were done. The physical tests such as the friability, disintegration and dissolution tests were carried out. In order to determine the tablets' potential to crumble or break when exposed to mechanical stress or abrasion, the friability test was conducted. The disintegration tests of expired amoxicillindrug were conducted with the help of a disintegration device, in which tablets are submerged in the dissolving media and time taken by the tablet to dissolve completely was noted.

The dissolution study was conducted in order to evaluate, the rate of dissolution under controlled conditions. The rate and degree of drug release from the expired amoxicillin tablet was noted. The results of the organoleptic and the physical test for the expired tablet are presented in Table no.1.

B. Evaluation of Soil Quality:

2.2 Collection of Soil Sample from the Land fill:

A composite soil samples were collected from the landfills in Mysore. The soil samples were allowed to air dry and sieved using a 2 mm mesh screen and placed in polythene bags for further analysis. The soil samples were analyzed using standard procedures [Standard methodology of Arun Kumar Saha (2008), GKVK Manual (1999)].

2.3 Chemical composition of Amoxicillin tablet and its usage:

Amoxicillin is a semi-synthetic penicillin antibiotic drug. The chemical name of amoxicillin is 6-[D(−)β-amino-p-hydroxypheny l-acetamido.] penicillanic acid. The International Union of Pure and Applied Chemistry (IUPAC) lists its systematic name as (2S,5R,6R)-6-[[(2R)-2-amino-2-(4-hydroxyphenyl)acetyl.]amino.]-3,3-dimethyl-7-oxo-4-thia-1-azabicyclo[3.2.0.] heptane-2- carboxylic acid. Therapeutically, amoxicillin is used as a broad spectrum of bactericidal activity against many gram-positive and gram-negative microorganisms. In general, amoxicillin is produced as amoxicillin trihydrate. Amoxicillin is used to treat bacterial infections, such as chest infections (including pneumonia) and dental abscesses. It can also be used together with other antibiotics and medicines to treat stomach ulcers. It's often prescribed for children, to treat ear infections and chest infections.

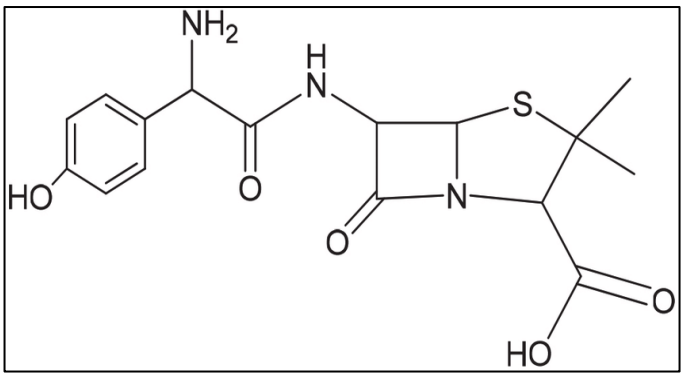


Fig.1. Chemical Structure of Amoxicillin

2.4. Experimental Procedure:

The landfill soil samples were processed and transferred into the pots with a capacity of 1 kilogram. The powdered expired amoxicillin tablets were added to the soil at different concentration like 1g, 5g and 10g. The selection of concentration was done based on the quantity of amoxicillin antibiotics disposed from the household wastes. This was confirmed during the initial survey of the pharmaceutical wastes disposal and quantification study. For each concentration, three trials were maintained with one control. The experimental setup was kept for observation for a period of 30 days, after the addition of the expired amoxicillin tablets. Throughout the observation period, a small amount of water was added regularly to maintain the moisture level in the pots. At an interval of 10 days, the soil samples were taken from all the pots. The soil samples collected at each interval were analysed for physico-chemical parameters in order to know the effect of expired amoxicillin on soil quality.

III. Results and discussions:

Table 1 Organoleptic Characterization and Physical Tests of Expired Amoxicillin Tablet	
Characteristics	**Expired Tablet**
Name of the tablet	Amoxycillin capsules
Layer	Capsules shells
Drug content	Carmoisine, titanium dioxide, tartrazine
Colour	Ponceau, Sunset yellow
Dosage	250mg
Odour	Faint fruity odour
Taste	An artificial strawberry-adjacent taste
Size	Common capsule size
Shape	Hard gelatin capsule shells size-2
Weight	Each tablet contains 0.351g
Therapeutic class	Penicillin-like antibiotic
Hardness test	NA
Friability	0.0065%
Disintegration	Around 45 minutes
Dissolution	Rate of dissolution of drug was 0.45% at 120 mins

The organoleptic properties of the expired amoxicillin tablet are presented in the table 1. From the table, following observations were made. The amoxicillin capsules were coated with a layer of capsules shells which consists of carmoisine, titanium dioxide and tartrazine. The colour of the capsules varied from ponceau and sunset yellow colour with a dose of 250mg. The odour appears faint fruity odour. The taste was found with additiveof artificial strawberry taste. The size of the capsule was found to be common capsule size with a shape of hard gelatin capsules shell size-2. Each tablet weighs about 0.351g. It belongs to a therapeutic class of penicillin-like antibiotic. The friability value was found to be 0.0065% and the time taken by the expired amoxicillin capsule to disintegrate was found to be 45 minutes. The rate of dissolution was found to be 0.45% at 120minutes. From the above properties, it was observed that, the rate of expired amoxicillin disintegration and its dissolution under varied environmental conditions will affect the soil quality.

Table 2. Physico-Chemical Characterization of Landfill Soil Sample Treated with Expired Amoxicillin Tablet

Soil Physico-Chemical Parameters		MC(%)	WHC(%)	BD (Mg/m^3)	PD (Mg/m^3)	Porosity(%)	pH	EC (ds/m)	Ca^{2+} (ppm)	Mg^{2+}(ppm)	Cl^- (%)	OC(%)	AN (Kg/ha)	K^+ (Kg/ha)	AP (Kg/ha)	SO_4^{2-} (ppm)
Normal Range		**1-1.65**	**-**	**1-1.65**	**2-2.65**	**30-65**	**6.5-7.5**	**1-2**	**700-36000**	**1200-15000**	**0.01-0.99**	**0.5-0.75**	**240-480**	**110-280**	**10-25**	**8-30**
Control values		**4.46**	**37.62**	**1.182**	**1.876**	**36.994**	**7.35**	**1.41**	**84.16**	**19.45**	**0.532**	**0.66**	**163.0**	**251.40**	**79.42**	**26.68**
Days	**Soil Samples Treated with Different Concentrations of Expired Amoxicillin Tablet**															
10th Day	**1g**	**6.2**	40.6	1.20	2.11	42.8	7.27	4.0	241	35	0.53	0.81	**378.3**	**1120.5**	**123.4**	**133.5**
	5g	**6.26**	41.3	1.22	2.2	43.2	7.4	4.13	250.6	36	0.59	0.86	**460.6**	**1282.7**	**129.1**	**195.7**
	10g	**6.30**	41.6	1.24	2.2	43.9	7.4	4.33	256.6	36	0.64	0.88	**464.6**	**1397.2**	**136.6**	**224.6**
20th Day	**1g**	**6.3**	41.4	1.26	2.28	43.9	7.57	4.4	258.6	709.6	0.69	0.88	**504.3**	**1505.6**	**172.5**	**293.6**
	5g	**6.6**	41.9	1.28	2.3	44.6	7.72	4.46	261	722	0.73	1.02	**622.3**	**1564.2**	**208.1**	**426.7**
	10g	**6.9**	42.8	1.30	2.34	44.8	7.95	4.63	262.3	744.3	0.77	1.08	**846.3**	**1645.8**	**334.0**	**551.4**
30th Day	**1g**	**7.2**	45.8	1.32	2.40	45.5	7.97	4.63	267	770.3	0.76	1.32	**1118.3**	**1718.4**	**424.2**	**645.7**
	5g	**7.38**	46.6	1.34	2.50	47.6	8.46	5.26	282.6	782.6	0.85	1.45	**1519**	**1892.**	**493.**	**718.1**

														4	**6**	
	10g	**7.43**	47.7	1.40	2.60	49.3	**8.45**	**5.26**	290.3	**791.3**	**0.95**	**2.02**	**1894**	**2008.5**	**555.0**	**1026.3**

[MC-Moisture content, WHC- Water Holding Capacity, BD-Bulk Density, PD-Particle Density, EC-Electrical Conductivity, Ca^{2+}-calcium, Mg^{2+}-Magnesium, Cl^{-}-Chloride, OC-Organic Carbon, , AN-Available Nitrogen, K^{+}-Potassium, AP-Available Phosphorus, SO_4^{2-}-Sulphates]

Fig 2. Graphical Representation of Physico-Chemical Parameters of Landfill Soil Sample without any addition of tablets (Control)

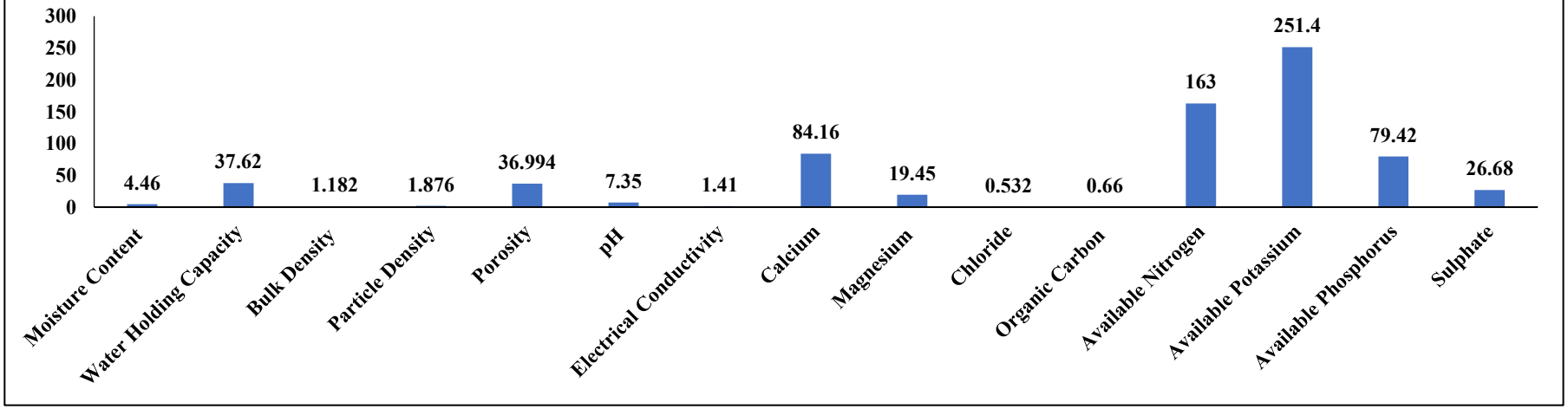


Fig 3. Graphical Represntation of Physical parameters such as MC, WHC, BD, PD, Porosity of landfill soil sample treated with expired amoxicillin medicines with different concentrations at an interval of 10th, 20th and 30th day

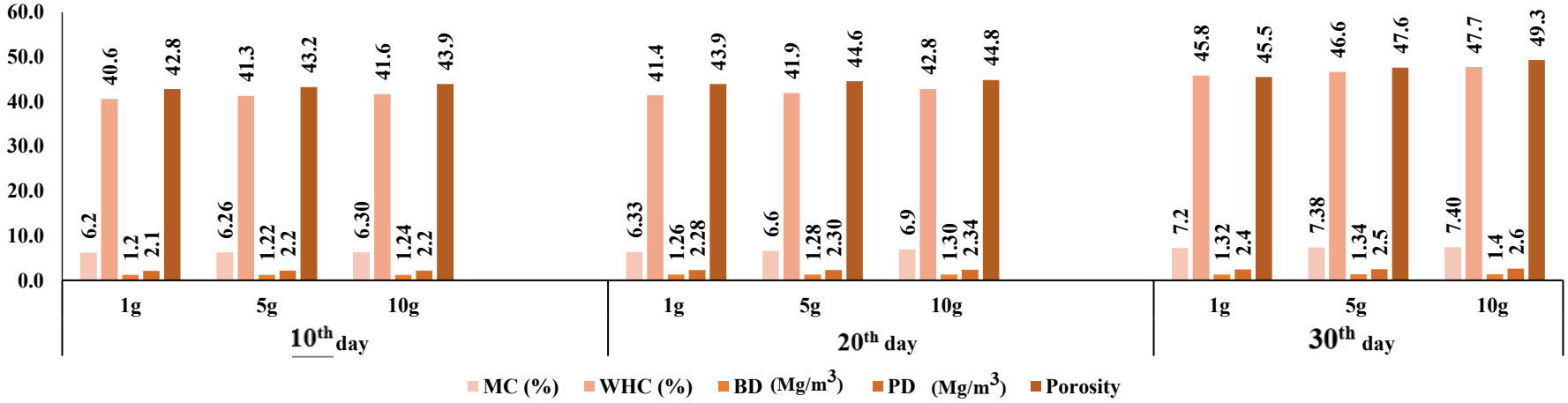
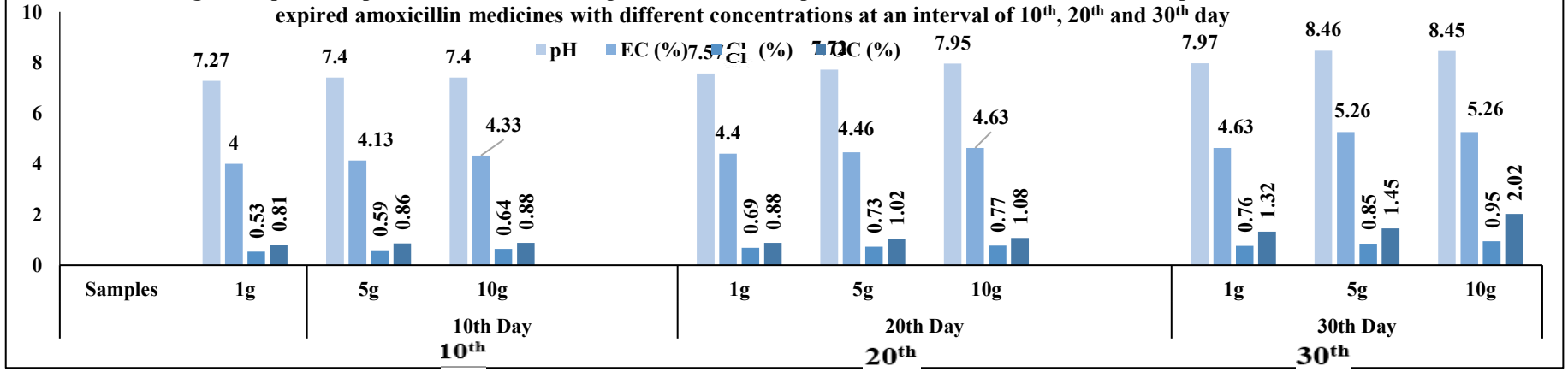


Fig 4. Graphical Representation of chemical parameters such as pH, EC, Cl^- and OC of landfill soil sample treated with expired amoxicillin medicines with different concentrations at an interval of 10th, 20th and 30th day



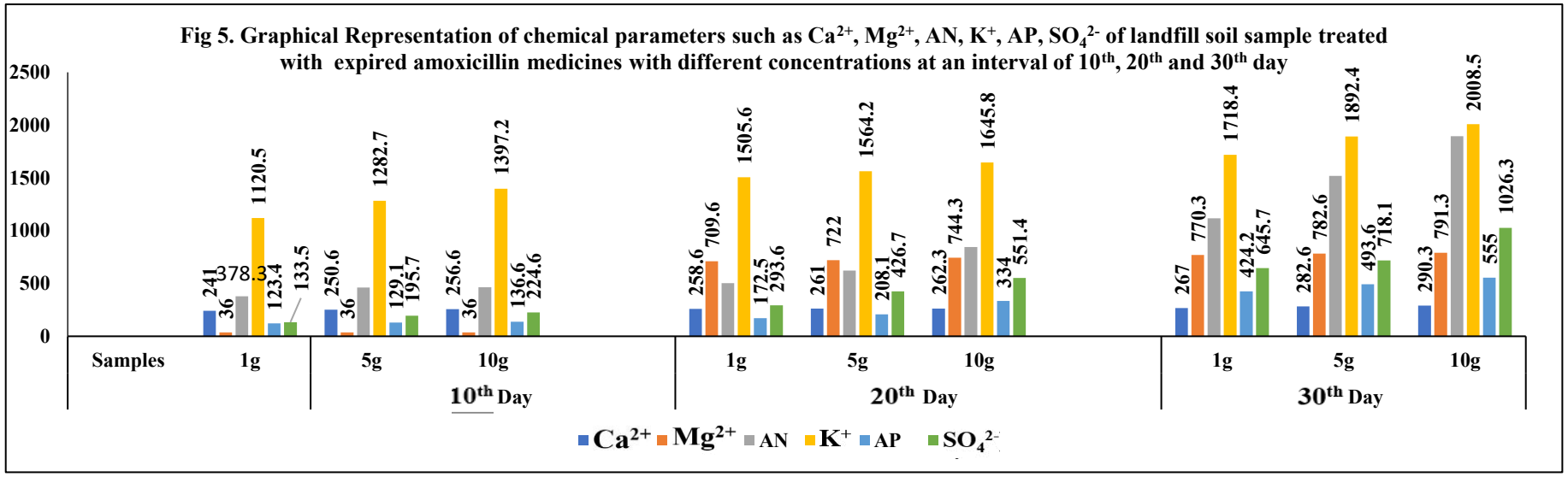


Fig 5. Graphical Representation of chemical parameters such as Ca^{2+}, Mg^{2+}, AN, K^{+}, AP, SO_4^{2-} of landfill soil sample treated with expired amoxicillin medicines with different concentrations at an interval of 10th, 20th and 30th day

The experimental results were presented in the table 2. For the interpretation, a comparative study has been done between the expired amoxicillin tablet treatment with the normal range of soil quality. The results obtained from the experimental analysis were presented as follows.

Moisture Content (MC): From the present study, the moisture content of the landfill soil treated with the expired amoxicillin was observed that, as the concentration increases, the MC also increased. The highest moisture content observed was 7.43% in 10g concentration of expired drug at 30th day interval. In comparison with the control and the soil quality parameters, the MC observed was higher. The Moisture is essential for the biodegradation of organic compounds present in the expired medicines. In the landfill environment, the microorganisms will break down organic matter more efficiently in the presence of moisture [6].This is the primary factor responsible for the rise in moisture level with respect to increase in the concentration of the expired tablet.

Water Holding Capacity (WHC): Water holding capacity refers to the ability of a material, such as soil, to retain water within its pores or structure. Impact of expired amoxicillin tablet on soil's ability to retain water, depends on the specific compounds present in the tablet [6]. In the present study, the lowest water holding capacity was found in 1g concentration at 10th day interval. The highestwater holding capacity observed was 47.7% in 10g concentration at 30th day interval.

Bulk Density (BD): The bulk density of the landfill soil treated with expired amoxicillin was observed that, as the concentration of expired amoxicillin increases, the bulk density valueswas found to be increased. The highest bulk density observed was 1.40 Mg/m^3 in 10g concentration at 30th day interval. The bulk density influences the movement and accumulation of gases generated during the decomposition of organic matter, including the expired medicine. In comparison with the control, the bulk density valuewas found to be higher [7].

Particle Density (PD): In the present research, in comparison with the control and the soil quality parameter, the particle density of the landfill soil treated with expired amoxicillin observed was higher. The highest particle density observed was 2.60 Mg/m^3 in 10g concentration at 30th day interval. Higher particle density leads to higher soil compaction which reduces the soil permeability [7].

Porosity: In the present study, the lowest porosity values observed was 42.8% in 1g treatment at 10th day interval. The highest porosity of the landfill soil treated with the expired amoxicillin was 49.3% in 10g concentration at 30th day interval. In comparison with the control, the porosityvalue was found to be higher.

pH: In the present study, the pH value of the soil sample treated with the expired amoxicillin was found to be increase with the increase in concentration. In comparison with the soil quality parameter and the control, the pH observed was very higher. The highest pH observed was 8.45 in 10g concentration of expired amoxicillin at 30th day interval. Many studies show that, the elevated pH results in generation of leachate [8].

Electrical Conductivity (EC): The electrical conductivity in the present study was found to be higher in comparison with the control and the soil quality standards. The highest electrical conductivityobserved in the present study was5.26 ds/m in 10g concentration of the expired amoxicillin at 30th day interval. Many studies observed that, high electricalconductivity will affect the enzymatic activity in soils [9].

Calcium and Magnesium [(Ca^{2+}) and (Mg^{2+})]: The Calcium and Magnesium were measured in terms of ppm in the present study. In comparison with the control and the soil quality standards, the Ca^{2+} and Mg^{2+} observed was lower. The highest calcium and magnesiumvalues obtained was 290.3ppm and 791.3ppm in 10g concentration of expired amoxicillin at 30th day interval. At 10th day interval with 1g concentration of the expired amoxicillin, the magnesium values observed was constant. As the concentration of the expired amoxicillin, the magnesium values were also found to increase.

Chloride (Cl^-): In the present study, the chloride values was found to be increase with the increase in concentrationof all the treatments. The lowest chlorideobserved was 0.53% in 1g concentration of expired amoxicillin at 10th day interval. The highest chlorideobserved was 0.95%in 10g expired drug concentration at 30th day interval. Chloride ions can facilitate the transport of other contaminants in the soil.

Organic Carbon (OC): The organic carbon of the soil sample treated with the expired amoxicillin was found to be gradual increase with the increase in concentration. The lowest organic carbonfound in 1g concentration of expired amoxicillin at 10th day interval and the highestorganic carbonobserved in 10g expired drug concentration at 30th day interval.

Available Nitrogen (AN): In the present study, the highest available nitrogen obtained was 1894 Kg/ha in 10g concentration at 30th day interval. In comparison with the control and the soil quality standard, the available nitrogen values observed was higher. Many studies showed that, the increase in nitrogen may primarily result from the degradation of amoxicillin and its nitrogen content present in it (Arun et al., 2020).

Available Phosphorus (AP): The available phosphorus in the present study observed was 555.0 Kg/ha in 10g expired amoxicillin concentration at 30th day interval. The phosphorus values were found to be higher in comparison with the control and the soil quality standard.

Potassium (K^+): In the present research, in control,the potassium values was found to be 251.40 Kg/ha. After the addition of expired amoxicillin, the potassium value was increased with the increase in the concentration of expired amoxicillin. The highest potassium obtained was 2008.5 kg/ha in 10g concentration at 30th day interval. Excessive potassium can inhibit the uptake of other essential nutrients by plants, leading to nutrient deficiencies [10].

Sulphate (SO_4^{2-}): When organic matter decomposes in landfills under anaerobic conditions, sulphur compounds can undergotransformations due to the influence of microorganisms, leading to the release of sulphates into the soil. The sulphate values observed in the present research was very much higher in comparison with the control and the soil quality standards. The highest sulphate value observed in 10g concentration at 30th day interval was 1026.3ppm.

IV. Summary and Conclusions:

Based on the pilot study conducted with the treatment of expired amoxicillin antibiotic tablet into the landfill soil sample, it was observed that, the physical parameters such as moisture content, water holding capacity and particle density were found to be higher in comparison with the soil quality standards and control. From the organoleptic properties and physical tests of an expired amoxicillin tablet, it was found that, the rate of dissolution of expired drug was 0.45% at 120 minutes which indicated quick dissolution of expired amoxicillin under various environmental conditions and has shown its detrimental effect on soil quality. From the study, it was observed that, the chemical properties in expired amoxicillin treatments, the pH, organic carbon, electrical conductivity, chloride, available nitrogen, potassium, sulphate and phosphorus values was higher in comparison with the soil quality standards and control. From the overall study, it can be concluded that,disposal of expired antibiotics is a matter of environmental concern otherwise, it can lead towater pollution. This inturn affects the growth of plantsand animals. So, the proper management of expired amoxicillin antibiotics has to be done form the household levels before disposing through the domestic wastes. So awareness need to be created among the community to prevent the disposal of antibiotics along with the household wastes.

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