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DEVELOPMENT OF NEW TECHNIQUES FOR ENHANCEMENT OF SOIL FERTILITY

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Abstract
This study is designed to improve the soil fertility by using different polysaccharide (*Spirulina platensis* and Gums) techniques. In this experiment, commercially available powder of *Spirulina platensis* and Gums (guar gum, tragacanth gum, alginate gum) wereused to increase the soil fertility. The solution of these polysaccharides was sprayed on the soil at different time intervals. The concentration of metals in the soil was determined using atomic absorption spectroscopy.Samples of untreated soil were utilized as a control. The findings of this experiment showed that utilizing *Spirulina platensis* and Gums (guar gum, tragacanth gum, and alginate gum) successfully increased the soil fertility. A significant increase in the levels ofzinc, copper, lead, and cadmium was observed ($P<0.05$).Using a spray on the soil resulted in an increase in the quantity of components that were in short supply.This method will further have a substantial impact on plant growth and fruit production.

Keywords:Gums, Polysaccharide, Soil fertility,*Spirulina platensis*, Spray

1. Introduction

Plant growth and development may be supported by soil fertility, i.e., may serve as a habitat and boost crop production over time [1]. Soil productivity is determined by complex interactions among its chemistry, physics, and biology. Good farming methods strive to regulate the many components that make up each of these traits to optimize or grow agricultural productivity and reduce environmental damage. Economists stated that a healthy economy and the eradication of poverty may both be influenced positively by good soil. Lack of knowledge, inappropriate methods of fertilizer delivery, and the restricted usage of organic compounds have all contributed to poor soil quality and nutrient insufficiency. Agricultural waste management, insufficient fertilizer levels, the use of waste and plant leftovers as a source of fuel and feed, and the lack of effective soil conservation measures and cropping patterns all contribute to the problem [2,3]. Seyoum B. (2016) claims that the conversion of natural systems into agricultural land ecosystems has resulted in soil shortage [4]. Crop production for agricultural needs and the importance of this information is dependent on the influence of conventional and new farming practices in agro-systems on soil characteristics, development of such a combination as microbial plant soil, and biosynthesis.

A lot of focus is being placed on enhancing farming systems and developing new technologies for minimal tillage and technical means that contribute to increasing soil fertility effectively while using the least amount of energy and labor possible, as well as increasing the lifespan of machinery and mechanisms while also maximizing their effective use in other countries [5]. Crop seeding is traditionally done in phases, with each step including a different kind of soil preparation (clearing fields, disking, harrowing, threshing, and sowing) to prepare the land for planting. India's economic development is intimately correlated with agricultural growth due to its forward and backward connections to the manufacturing and service sectors[6].Modern farming and soil preparation needs cannot be met by this technique, which has neither soil protection nor the ability to prepare the soil for the planting of crops on ridges [7]. It is also agronomically and economically unjustified since labor productivity decreases, labor and money costs rise, soil compaction and destruction of soil structure occur due to repeated passage of machines, soil preparation time is delayed and the soil is intensively dried, which entails a decrease in agricultural crop yield.
Various contaminants have contaminated soil to varying degrees in many different places. According to the industry, which ranges from manufacturing to mining power/energy generation, different pollutants are released into rivers. The health of people might be harmed by soil contamination. For instance, it could result in cancer, gene mutation or toxicity. Because of the inherent characteristics of heavy metals, soil heavy metal contamination is one of the most significant problemsWastewater irrigation has the potential to generate heavy metal soil contamination. Most of the wastewater is discharged in metropolitan areas by heavy enterprises. Information, goods, and pollution spread from urban to suburban areas.In developing nations, various industrial wastes (solid and liquid) particularly from textile industries, that include harmful metals including cadmium (Cd), arsenic (As), nickel (Ni), zinc (Zn), copper (Cu), mercury (Hg) etc. are released into the environment without sufficient treatment [8]. The main causes of environmental pollution with hazardous metals include a variety of sectors, including metallurgy, wood preservation, chemical, leather, dyes, and pigments. As a result, hazardous metals are being exposed to millions of individuals working in a variety of businesses throughout the globe, including those producing pigment, tanning leather, etc., which has major environmental and health consequences. Heavy metals may come from a diversity of sources, but industrial processes, including the burning of fossil fuels, the production of goods, and the discarding of trash, are the biggest causes of soil adulteration[9].Due to soil ingestion, inhalation, and skin contact, hazardous metal-polluted soil in industrial regions may pose serious threats to human health
Biologically active substances, algal polysaccharides have a wide range of potential uses.*Spirulina* polysaccharides have been shown to exhibit biological activity when extracted for medicinal use [10]. The seaweed-derived active polysaccharides and oligosaccharides exhibited a broad variety of uses in terms of growth stimulation, soil fertility, and plant

defense.Guar gum, exudate gums, tragacanth gum, microbial gums, seaweed gums (alginates), and animal polysaccharide gums are some of the several forms of these gums. Trees and shrubs release amorphous gums in the form of tear-like, smeared buds, lumps, or masses when under stress. They produce glassy, hard exudates that come in a variety of colors, including white (tragacanth gum), dark brown (tragacanth gum), etc. after being exposed to the sun. Therefore, the research of microalgae polysaccharides in agriculture seems promising for the creation of novel plant growth-stimulating products.The purpose of this study is to find a new technique to improve soil fertility and plant growth by using polysaccharides extracted from microalgae and gums.

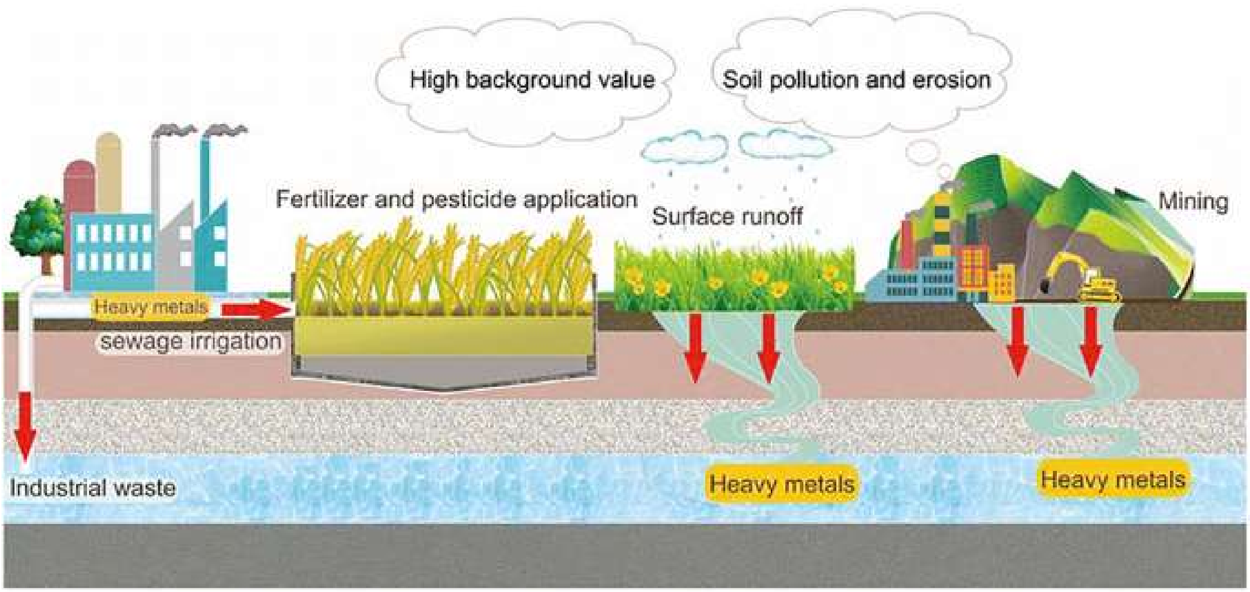

Figure 1. Decreasing of soil fertility by various parameters

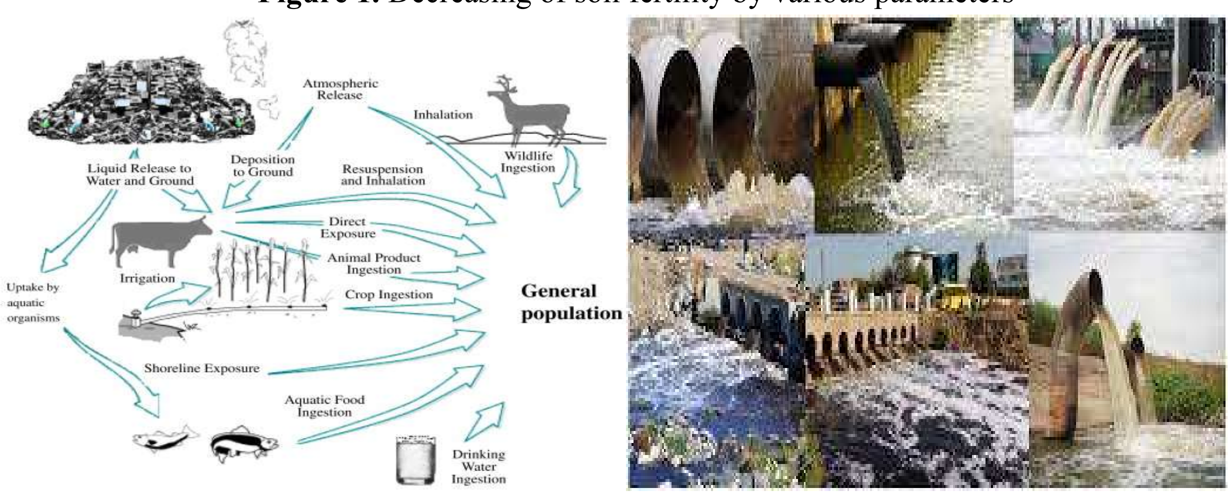

Figure 2.a) Disposal of wastes into river water and adjoining soil and its after-effects, b)Photo grid depicting pollution due to textile effluents & garbage disposal

2. Material Method

2.1 Study Design

The research area is in Rajasthan's Pali district, which can be found between latitudes $24^0$45' and $26^0$29' North and longitudes $72^0$47' and $74^0$18' East. Pali is located along the bandi river. Bandi river is major tributary of luni river. The city has several textileprocessing unit located in various industrial area. The soil sample were collected from different site of bandi river and transferred to the lab in polythene bags and labled to avoid a mix up to the different soil samples.

2.2 Study Design

Commercially available polysaccharide was used to carried out the study. Dried biomass of *Spirulina platensis* from WB Im-und Export W. Beringer& Co. GmbH (Sigma Aldrich; India).In Gum (guar gum, tragacanth gum, andalginate gum),dilute solutions of guar gum and sodium alginate (Sigma Aldrich) were utilized to form biopolymer film on the surface of the soil. Using a Malvern 3600 thermofisher, dynamic light scattering was used to determine the polymers' molecular weight (India). Sandy loam soil was procured from institutenear Rajasthan, India.Before usage, the soil thoroughly dried at 105 °celcius to get rid of any remaining water. It has a molecular mass of about 8.4x105 Da and an elongated shape of 4,50019. Merck (Delhi, India) provided CEROTRAG 887, a tragacanth gum. About ≥ 80percent of the gum that was recovered was galactomannan. The amounts of guluronic and mannuronic acids that make up alginate's linear structure vary depending on the source.

2.1 Spray solution preparation

- **Microalgae**

  Plants were treated with a solution of total polysaccharides extract (TPE), which was then sprayed on them (3 gL^{-1} of total polysaccharide extract dissolved in distilled water, pH 6.0).

- **Gum (guar gum, tragacanth gum, alginate gum)**

  The powdered biopolymer was mixed with DI water for 24 hours until it was completely dissolved. To ensure that all the stock solutions were identical, they were diluted with DI water and then thoroughly mixed for an hour.

2.2 Soil material and culture conditions

- **Microalgaeand Gum (guar gum, tragacanth gum, alginate gum)**

  The soil was sprayed twice with the solutions, 3 days apart. Soil that wasn't treated were used as a control.Spraying was done with a full pressurized 8002Voltas spray tip nozzle. For the first instance, a biopolymer solution was sprayed on soil in the pot. A drying oven at 105°Celsius for 24 hours was used to dry the soil after each treatment. All the polysaccharides were sprayed individually one after the other. To see the created polymer film in soil samples, a Leica M165 Celsius stereomicroscope was used, and a 5-megapixel DFC420 microscope camera was used to take pictures.

Figure 3. Polysaccharide powder (gums and microalgae).a) Alginate gum, b)Tragacanth, c)Spirulina powder, d) Guar gum

2.3 Atomic Absorption spectroscopy

An atomic absorption spectrometer (AA500, Pg equipment) was used to determine the concentration of elements (K, Cu, Cd, Pb) in the selected soil samples. In addition to the Flame Atomizer and Graphite Atomizer, there is an option to switch between them in the software. Agricultural, environmental, medical, healthcare, geology, petrochemicals, and conductivity by Conductivity meter Model NDC-736 are just few of the sectors that employ this automated equipment. According to BIS and ASTM standards, several volumetric and instrumental analytical methods were utilized to investigate additional physico-chemical properties. Atomic absorption spectroscopy is used to conduct both quantitative and qualitative evaluations of an element. The approach relies on determining the quantity of optical light absorbed by gaseous atoms. The approach is easy to use and may be used tosoils, sediments, industrial and residential waste, surface, and subsurface water, as well as industrial and domestic waste. Using a Perkin Elmer Atomic Absorption Spectrophotometer and burning acetylene, nitrous gas, and compressed air, the amounts of trace elements in single-elemental standard samples were examined. Gases flow at a provided pace based on the element of interest. Flame atomizers include both complete consumption burners and pre-mixed burners. By increasing the temperature of the rod, the chamber's sample was dried and atomized. A hollow-cathode lamp is made using the metal in the chemical being researched. The anode is of tungsten, and each HClhad certain current to operate properly. There was less background noise at higher voltages, making the emission brighter or clearer. A deuterium lamp was used to determine the background wavelength. One percent (v/v) HNO_3 was used to make the standard and blank solutions. Using a graduated flask with a volume of 100.0 mL, three separate concentrations of stock standard solution (100 mg/kg) were generated. The flask was then refilled with distilled water to the correct level.

2.4 Statistical analysis

Freshly prepared samples were used for every measurement, which was done at least 3 times. Data were presented as mean and SD.A paired sample T-test was performed to determine if there was a significant difference between the treatment levels.

3. Result

Various studiedparameters in the soil samples treated with different polysaccharides including *Spirulina platensis*, Guar gum, Tragacanth and Alginate gum are represented in table 1.

Table 1. Levels of Cr, Pb, Cd, Cu, Fe and Zn in soil samples treated with different polysaccharides.

Samples	Cr (ppm)	Pb (ppm)	Cd (ppm)	Cu (ppm)	Fe (ppm)	Zn (ppm)
Control	0.17 ± 0.08	32 ± 1.58	0.12 ± 0.05	5.2 ± 2.16	53387.6 ± 7163.6	64.2 ± 6.1
Spirulina platensis	0.06 ± 0.01	35.6 ± 1.51	0.07 ± 0.02	10.2 ± 1.92	32762.4 ± 6648.08	28.8 ± 3.5
Guar gum	0.08 ± 0.01	37.2 ± 0.83	0.07 ± 0.02	11.2 ± 3.11	30515 ± 3740.3	29 ± 2.7
Tragacanth gum	0.07 ± 0.02	35.8 ± 1.92	0.05 ± 0.02	13.8 ± 1.78	29951.4 ± 4706.8	31.2 ± 4.7
Alginate gum	0.06 ± 0.01	36.2 ± 1.30	0.06 ± 0.03	16.4 ± 2.07	24267.4 ± 1662.9	35.2 ± 3.1

Table 1. Levels of Chromium, Lead, Cadmium, Copper, Iron and Zinc in *Spirulina platensis*, Guar gum, Tragacanth and alginate treated soil

All the heavy metals were present in higher amount as compared to the limited concentration in the control samples. In soil samples treated with various polysaccharides, the concentration of heavy metals were present in limited concentration.The average level of chromium and lead in soil were observed to be higher in Guar gum treated soil (0.08 ppm and 37.2 ppm, respectively). The Cadmium levels were higher in soil samples treated with *Spirulina platensis* and Guar gum (0.07 ppm), whereas copper levels were observed to be higher in Alginate treated soil (16.4 ppm).

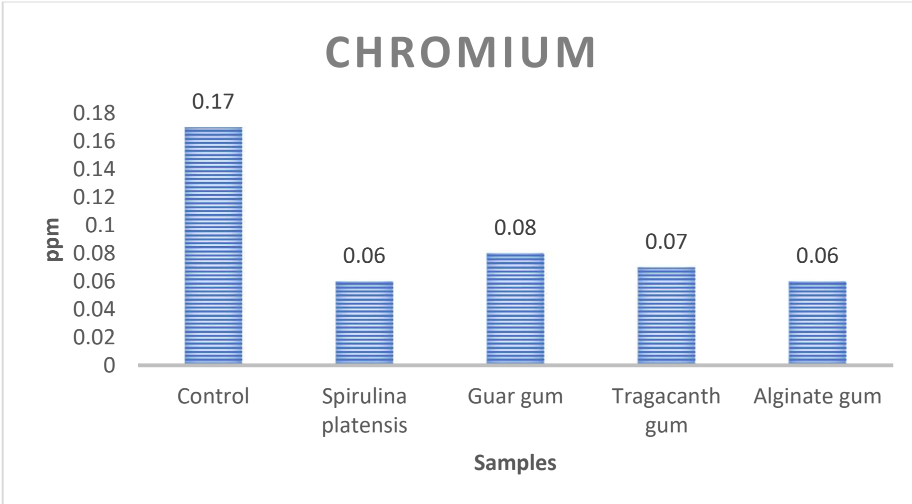

Figure 4. Average level of Chromium in the soil treated with various polysaccharides

Figure 3 represents the average level of Cr in soil treated with various polysaccharides. An accepted level of Cr was observed in soil treated with polysaccharides as compared to the control (0.17 ppm). The level of Cr was 0.08 ppm in Guar gum treated soil followed by Tragacanth (0.07 ppm), Alginate (0.06 ppm) and *Spirulina Plantensis* (0.06 ppm).

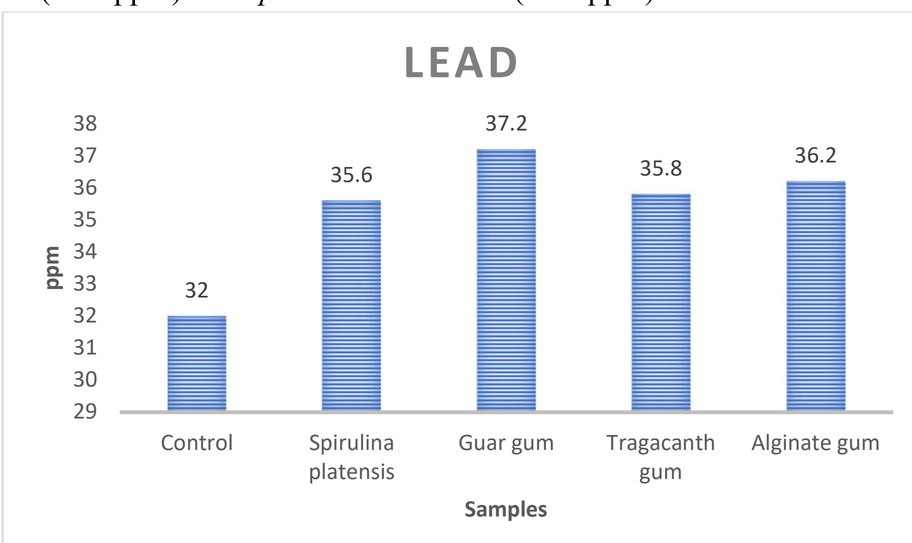

Figure 5. Average level of Lead in the soil treated with various polysaccharides

Average Lead level of soil treated with various polysaccharides and the control were depicted in figure 4. The lead levels were found to be 37.2 ppm in Guar gum treated soil (37.2 ppm) followed by alginate (36.2 ppm), Tragacanth (35.8 ppm) and *Spirulina Plantensis*(35.6 ppm). In control group, the concentration of lead was found to be lower than the average concentration fore fertile soil (32 ppm).

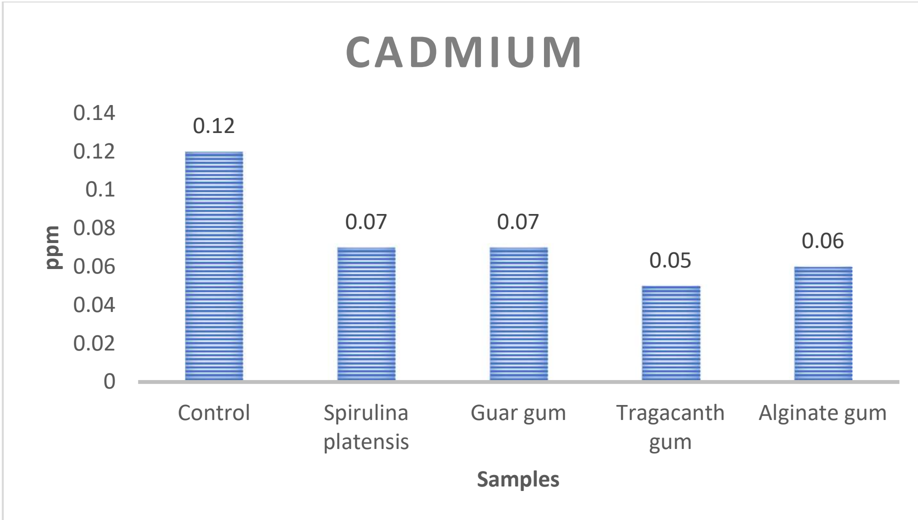

Figure 6. Average level of Cadmium in the soil treated with various polysaccharides

Figure 5 represents the average level of Cadmium in soil treated with Guar gum, alginate, Tragacanth and *Spirulina Plantensis.* The level of cadmium were 0.12 ppm in control, which is higher than the limited concentration, whereas in soil treated with Guar gum it was 0.07 ppm followed by *Spirulina Plantensis*(0.07 ppm), Tragacanth (0.05ppm) and Alginate gum (0.05 ppm).

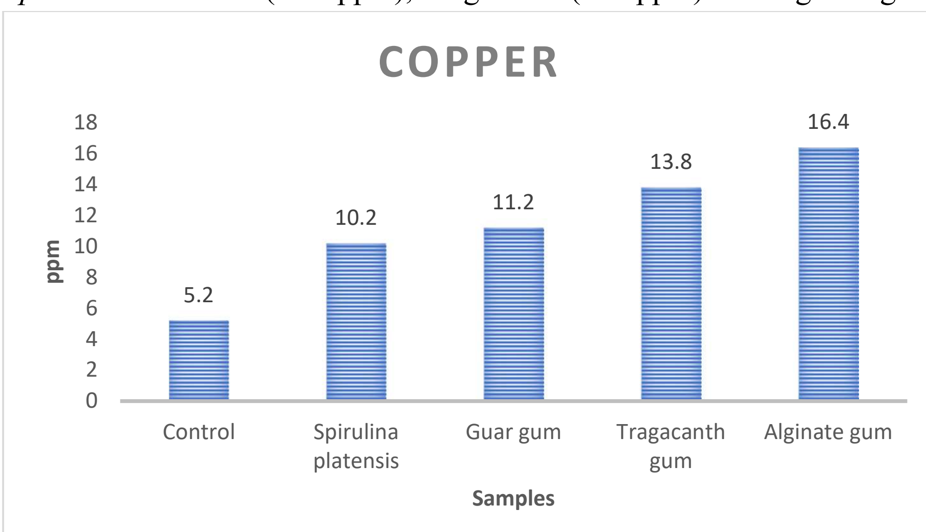

Figure 7. Average level of Copper in the soil treated with various polysaccharides

Average copper levels in soil treated with different polysaccharides are represented in figure 6. The Cu levels were found to be lower in control sample as compared to the polysaccharides treated soil samples. In Alginate, Tragacanth, Guar gum and *Spirulina Plantensis*, the Cu levels were observed to be 16.4 ppm, 13.8 ppm, 11.2 ppm and 10.2 ppm respectively.

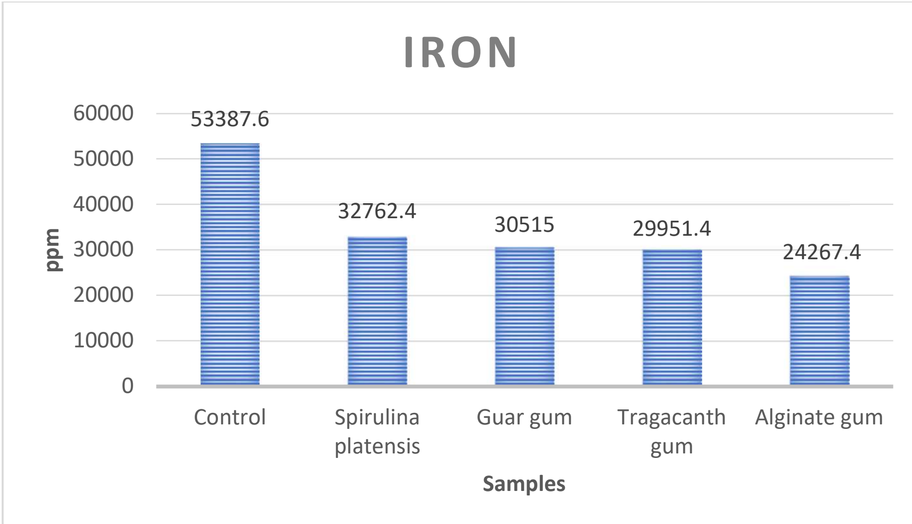

Figure 8. Average level of Iron in the soil treated with various polysaccharides

The average concentration of iron in soil treated with different polysaccharides are represented in figure 7.The higher concentration of iron was observed in the control sample (53387.6 ppm) as compared to the soil samples treated with polysaccharides. The polysaccharide treated soil samples contain limited concentration of iron in Alginate, Tragacanth, Guar gum and *Spirulina Plantensis*at 24267.4 ppm, 29951.4 ppm, 30515 ppm and 32762.4 ppm respectively.

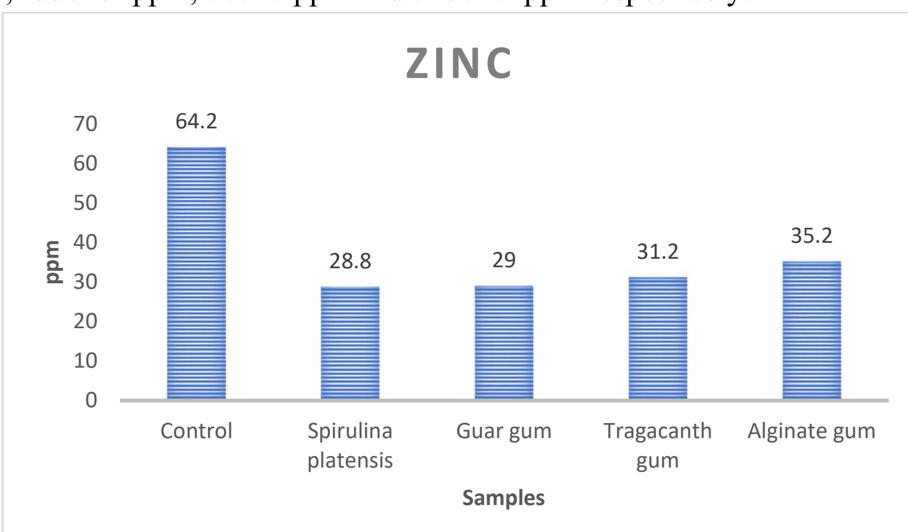

Figure 9. Average level of Zinc in the soil treated with various polysaccharides

Figure 8 represents the average level of zinc in soil treated with Guar gum, alginate, Tragacanth and *Spirulina Plantensis.* The level of cadmium were 64.2 ppm in control, which is higher than the limited concentration, whereas in soil treated with Guar gum it was 28.8 ppm, in *Spirulina Plantensis,* it was29 ppm,31.2 ppm in Tragacanth and 35.2 ppm in Alginate gum treated soil samples.

Table 2. Significance values of various metals in soil treated with various polysaccharides and the control.

	Significance value (p)					
	Cr (ppm)	**Pb (ppm)**	**Cd (ppm)**	**Cu (ppm)**	**Fe (ppm)**	**Zn (ppm)**
Control - *Spirulina platensis*	0.003	0.009	0.004	0.001	0.010	0.001
Control - Guar gum	0.008	0.000	0.000	0.017	0.004	0.001
Control - Tragacanth gum	0.004	0.064	0.002	0.005	0.003	0.001
Control - Alginate gum	0.002	0.000	0.009	0.003	0.000	0.000

Table 2 represents the significance values of chromium, lead, cadmium, copper, iron and zinc between the control and the experimental samples (Guar gum, alginate, Tragacanth and *Spirulina Plantensis*). As per data, a highly statistically significant difference was observed in zinc levels of the soilbetween control and the experimental samples ($P<0.05$), whereas other metals also showed statistically significant difference between control and the experimental samples ($P<0.05$), except lead levels in tragacanth gum treated soil which showed non-significant difference as compared to the control ($P>0.05$).

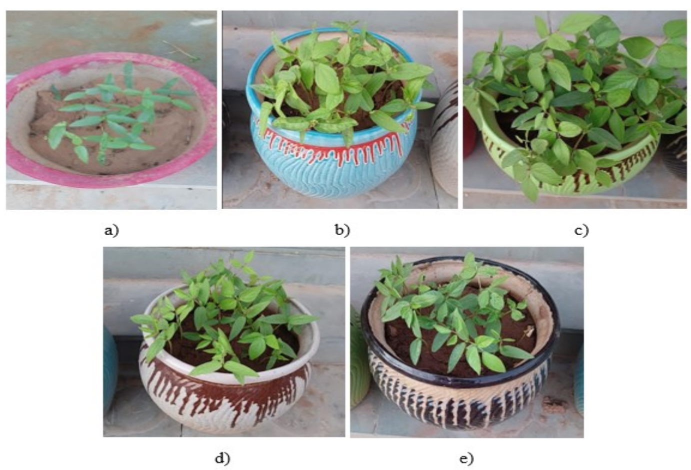

Figure 10. Growth of non-treated (control) and polysaccharide treated plant samples. a) control plant, b) Alginate gum spray, c)Tragacanth gum spray, d)Spirulina spray, e)Guar gum spay

4. Discussion

Many major technical applications, such as environmental and soil fertility, have relied on the utilisation of polysaccharides as a replacement for (or as a complement to), synthetic moieties in the production of hydrogels (ordinary or superabsorbent). Spectrochemical techniques have been utilised to assess the elemental composition of soil digests and soil extracts by researchers. Determine the soil's trace concentrations of both essential and non-essential components. Analyte elements such as Cd and Pb necessitate the inclusion of matrix modifiers to avoid volatile loss of analyte during pyrolysis and to enhance the volatility of matrix components [11]. In the present study, seeds were immersed in *Spirulina* products, which can serve as a rich source of novel and biochemically active natural compounds.For elements with complicated Zeeman splitting patterns (all elements of interest except Mg, Ca, Sr, Ba, Cd, and Zn), sensitivity may be lowered because some analyte absorption may be incorporated in the background [12].Tomato plants were researched by Aghofack-Nguemezi et al. (2015), who found that the aqueous extract of *Spirulina platensis* had a positive influence on growth and development. Plant length and diameter rose by 19 percent and 33 percent, respectively, upon foliar sprayed with aqueous extract (3%) [13].

In another study by Dehghan et al (2015),the findings show that biopolymers reduce the collapsible soil's maximal dry density and permeability. The results also suggest that the curing time and biopolymer quantity affect strain-stress curves. Because of the interactions between the the fine-grained soil particles and biopolymer strings, the findings of the SEM test also demonstrate changes in the morphological properties of the soil. In general, the findings imply that stabilisation of xanthan and guar gums plays a significant part in improving the mechanical characteristics of fine-grained collapsible soil, leading in a sustainable and environmentally acceptable alternative to conventional soil additives [14].

In general, HM-contaminated soils exhibit poor physiochemical and biological characteristics. Poor soil organic matter, low fertility, micronutrient imbalance, toxicity, low nitrogen and phosphorus availability, high electrical conductivity, and an extreme pH are all detrimental soil chemical features [15].

According to Ning et al., (2016), applying pulverous and granular steel slags at a rate of 1-3 percent (w/w) to acidic soils decreased the acid exchangeable fractions of metals and significantly reduced Cd, Cu, and Zn concentrations in rice tissues when compared to a control plant by 88, 92, and 74%, respectively [16].

5. Conclusion

Results obtained from this study showed that, there are variations in the metal contents of the soil. After applying of spray on soil the deficient amounts of elements increased in soil. An increase in the concentration of lead and copper were seen in guar gum, alginate, tragacanth,and *Spirulina platensis*,decrease in the level of cadmium, chromium, iron and zincwasobserved in alginate and guar gum tragacanth and *Spirulina platensis*. All the samples showed better result as compared to the control. The sprayed techniques help the soil in fertility. Elementsvaries their role in soil fertility. In future heavy elements spray on the soil can sort out optimum condition for soil fertility.

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