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Adsorption Efficacy of Plant Waste Dry Biomass in Aqueous Nickel (II) Ions and Responses on *Pennisetum americanum* L.



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ABSTRACT

Assessment of adsorption efficacy of various plant waste dry biomasses in nickel chloride treated *Pennisetum americanum* seedlings were grown in pots filled with mixture of red, black and sandy soil. Simultaneously, control (water) and control (6mM nickel chloride) plants were also maintained. The effect of various adsorbents accelerated to restore the growth of the plants. The impact of adsorbents on the biochemical constituents in terms of free amino acid, soluble proteins and glucose was studied. The level of free amino acid content was high in treated seedlings. The accumulation of photosynthetic pigments, biochemical constituents in leaves is considered to be an indication of efficient metabolic status than its counter parts. Further, the scavenging enzymatic activities were decreased in increased concentration of adsorbents application reveals the stress reliving nature of plants. Thus an overall assessment of plant in terms of growth, pigment composition, biochemical constituents and enzymatic activities has exhibit the retrieval efficacy of plant waste dry adsorbents from the nickel chloride treated *P. americanum*.

INTRODUCTION

Heavy metal pollution and its toxicity to the environment is one of a major problem faced by several developed and under developing countries, because of the rapid increase in population and industries in and around cities. Pollution refers to the addition of foreign material to our surroundings or changes in physical and chemical constituents of nature which may directly or indirectly affect the environment either immediately or after sometime. Heavy metal pollution in water is a major environmental problem facing the modern world. The global heavy metal pollution is increasing in the environment is due to increase in number of industries. Many industrial waste water contain heavy metals like cadmium, lead, zinc, cobalt and chromium.

The rapid industrialization in developing countries had led to tremendous pressure on the available finite water resources. This phenomenon is quite evident in the areas where water intensive industrial units like distilleries, paper and pulp, tannery, textile etc, thrive rapidly. Among the various kinds of pollution caused by industrialization, the problem of water pollution due to industrial effluents has attained greater dimensions in India. Indiscriminately discharged industrial effluents naturally affect the water quality as well as natural ecosystem. These problems can be overcome by means of proper utilization of waste water because the waste water act as source of plant nutrients, irrigation and thus alleviate the food grain demand.

A number of industries produce large volume of waste water requiring proper disposal. Lack of suitable treatment technologies and disposal facilities is a major hindrance to industrial expansion. The recycling options of waste water includes land applications, use in irrigation, forestry, application to constructed wetlands or artificial marshlands. Sometimes, industries produce highly toxic effluents, which can neither be thrown into water bodies not used for agricultural purpose as the toxic elements may enter the food chain through plants, animals and fish. This effective management of waste water brings economic benefits and protects fragile ecosystems from degradation.

In India many industries are using heavy metals in their process and exiled out without proper treatment. Metals are released into the environment leads wide. Nickel is a common pollutant arising from industries such as electroplating, metal processing and paint formulations. Up to that acceptance doses, nickel poisoning causes cyanosis, cancer in lungs,

nose and bones. Thus, it is necessary to remove them from industrial waste water. Several methods such as chemical precipitations, coagulations, ion exchange and adsorption are generally used. Owing to high and expensive cost, adsorption was reported as an efficient and economic feasible option.

Biosorption can be defined as a non-directed physic-chemical interaction that may occur between metal species and plant cells. It is a biological method of environmental control and can be an alternative to conventional contaminated water treatment facilities. It also offers several advantages over conventional treatment methods including cost effectiveness, efficiency, minimization of chemical or biological sludge, the requirement of additional nutrients and regeneration of biosorbent with possibility of metal recovery. In the present study was aimed to assess the biosorption efficacy of dried biomass such as *Palmyra* Tuber Skin, Karingali Roots, Tea leaves and *Pista* shell against aqueous Ni (II) ions treated *P. americanum* L. seedlings.

MATERIAL AND METHODS

Seed Source and Cultivation of Plant

Seeds of *Pennisetum americanum* (L) var. T9 were obtained from local seed centre, Karur. The healthy and uniform seeds of *P. americanum* were surface sterilized with 0.1% mercuric chloride for 1 minute and then it was washed 3 times with distilled water.

Adsorbents Used

1. Pista shell (Sample-1)

Botanical name: *Pistacia vera*, L (Anacardiaceae)

2. Karingali Roots (Cutch tree) (Sample-2)

Botanical name: *Acacia catechu* L (Mimosaceae)

3. Palmyra Tuber skin (Sprout) (Panankilangu) (Sample-3)

Botanical name: *Borassus flabellifer* L (Arecaceae)

4. Tea leaves (Sample-4)

Botanical name: *Camellia sinensis* L (Theaceae)

Preparation of Adsorbents

The adsorbents used in the present study were collected from various sources and these were shade dried and finely powdered. The dry powder of these adsorbents were mixed with nickel chloride (6 mM optimal concentration) solution separately and kept in mechanical shaker for 24 hrs. Later it was filtered and added to soil bed of experimental seedling.

Experimental Plant

Seedlings of *P. americanum* L procured from local seed centre was surface sterilized in 0.1% mercuric chloride and were depleted of micro and macro nutrients. It was grown in different troughs containing the mixture of red, black and sandy soil in the ratio of 1:1:1. After a period of 3days, the seedlings were subjected to treatment for 7days. Control was also maintained with water and 6mM Nickel chloride (Optimal concentration) alone treated plants. After 10 days treatment, the following parameters were observed in experimental and control plants.

Growth parameters

For all the growth parameters, reading was taken for 5 samples and the average with their standard error is represented. The following parameters were analyzed such as estimation of shoot length, estimation of root length, estimation of fresh weight, estimation of dry weight and estimation of Leaf area.

Photosynthetic pigment, Biochemical parameters and Enzyme activities

The amount of chlorophyll 'a', chlorophyll 'b' and total chlorophyll was calculated using the formulae of Wellburn and Lichtenthaler (1984). Estimation of carotenoids by Anthrone method, (Jayaraman, 1981), estimation of protein by estimated by Lowry's method (1951), estimation of free amino acids by Ninhydrin assay method (Jayaraman, 1981), estimation of leaf Nitrate determined by the method of Catado *et al.*, (1978), estimation of *in vivo* Nitrate reductase enzyme activity by Jaworski method (1971). Enzymatic activities such as Nitrate

reductase (Jaworski *et al.*, 1971) Catalase (Kar and Mishra, 1976) and Peroxidase (Addy and Goodman, 1972) were analyzed.

RESULT AND DISCUSSION

Growth Characteristics

The results of application of various adsorbents treated (S1, S2, S3 and S4), nickel chloride was applied individually on *P. americanum* L seedlings are presented in Table 1. Application of various adsorbents treated nickel chloride was caused significant increase in the growth of *P. americanum* seedlings. The increase was about 18% in the seedlings with S4 adsorbents. Similarly fresh weight, dry weight, leaf area and plant growth rate were also increased significantly with various adsorbents than the Nickel chloride (6mM) alone treated plants. The photosynthetic pigment such as chlorophyll 'a', 'b', total chlorophyll and carotenoid contents were increased with various adsorbents. The total chlorophyll content and carotenoid was increased to about 49% in S4 adsorbents than the control of *P. americanum* seedlings (Tabl-2 and Fig.1-4).

The result obtained on the present study indicated that, increase in concentration of Nickel chloride results in decrease in the shoot length and root length of *P. americanum* L. Winter halder, 1985 proved that the dry matter yield of tops and roots of oats decreased with increased zinc chloride level. Zinc chloride reduces the possibility of successful seedlings establishment was observed in germinating grass seeds during the revegetation in acid soil in which concentration of zinc and other metals very high.

In the present study highest total leaf area and plant growth rate was observed S4 treated nickel chloride. Promotion of greater leaf area might have resulted in higher yield of plants. The rapid adsorption and removal of nickel by various adsorbents indicated a high affinity of available surface groups on adsorbents for heavy metals. The highest value of accumulation and removal of heavy metals was observed in the leaf and root of the test crop (Michael Kumi *et al.*, 2013).

The leaf area and total chlorophyll are found to increase with the various adsorbents. This indicated that, the various adsorbents enhanced not only the leaf area but also the content of photosynthetic pigments which finally led to increase in the plant biomass. An increase in

leaf area and pigment content has been reported after adsorbents application by Ashoke *et al.* (2010).

Biochemical Characteristics

Various adsorbents may contain some cellulosic hydroxyl group which can easily bind with positively charged metal ions (Okonkwojo *et al.*, 2014) The impact of various adsorbents on the biochemical constituents was studied of free amino acids, soluble protein and starch content. The level of free amino acid content was high in treated seedlings. The accumulation of soluble protein in leaves is considered to be an indicating of efficient metabolic status various adsorbents.

The result obtained on the glucose, amino acid, and leaf nitrate content also revealed a increase in these content in plants treated with various adsorbents (Table-3). The same result was observed by Mansour *et al.*, (2005) in Linn seeds. The elevation in protein may be due to interference of adsorbents with the enzyme activity, pigments synthesis, photo synthesis and nitrogen metabolism (Chien *et al.*, (2000). As the major soluble protein in the leaf is only RUBP case, the enzyme involved in photosynthesis and any inhibition in the photosynthesis will also affected the leaf protein. Hence it can be related with various adsorbents act as inducer.

Enzymatic Activities

The activities of scavenging enzymes such as catalase, peroxidase, nitrate reductase and superoxide dismutase were analyzed and found to decrease with various adsorbents treated *P. americanum* seedlings. For example, the enzyme catalase activity was reduced to about 26%. However, the enzyme nitrate reductase activity was significantly increased with various adsorbents treatment than the control seedlings (Fig. 5-8).

Similar result observed that the peroxidase are enzyme which utilize hydrogen peroxide to oxidize a wide range of oxygen donors such as phenolic substances, cytochrome etc., as reported by Balasinha (1982). In the present study, an enhanced peroxidase activity with the increase in the concentration of Nickel chloride was observed. Whereas, during various adsorbents treatment, activity of peroxide was reduced and it is revealed that rectify the stressful effect caused by Nickel chloride in experimental plants.

Nitrate reductase is one of the cytoplasmic substrate inducible enzymes. The NR activity is decreased in Nickel treated plants. On contrary, various adsorbents treatment, there was increase in the NR activity. Observed reduction of leaf nitrate content after various adsorbents treatment indicates the increasing of NR activity.

CONCLUSION

The results confirmed that the PWB could be used as an effective, cheap and easily applicable adsorbent for Ni(II) removal without any treatment. Although the Ni(II) ions can be effectively recovered from the PWB by using desorbing agent, the PWB cannot be reused for adsorption because of the structure deterioration. PWB has proven to be an effective and alternative material for the removal of Ni(II) ions from aqueous media due to its excellent removal ability, availability, and low cost, as well as its features such as being able to be used without any chemical treatment and being environmentally friendly.

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Table-1: Effect of various adsorbents treated nickel on growth parameters of *P. americanum*.

S. No	Parameters	Control (Water)	Control (6mM NiCl ₂)	S1	S2	S3	S4
1.	Shoot length(cm)	13.2 ±0.031	10.12 ±0.01 (100)	12.5±0.034 (122)	11.2±0.021 (110)	11.9±0.13 (117)	13.0±0.14 (128)
2.	Root length(cm)	3.22±0.01	2.3±0.12 (100)	2.9±0.07 (125)	2.5±0.14 (108)	2.7±0.121 (117)	3.1 ±0.13 (132)
3.	Fresh weight(mg)	0.24±0.12	0.17±0.132 (100)	0.21±0.04 (123)	0.18±0.13 (106)	0.19±0.12 (111)	0.23±0.15 (134)
4.	Dry weight(mg)	0.0016±0.07	0.010±0.01 (100)	0.013±0.31 (130)	0.011±0.14 (110)	0.012±0.07 (120)	0.014±0.14 (140)
5.	Leaf area(cm ²)	3.51±0.12	2.85±0.11 (100)	3.21±0.02 (112)	2.93±0.12 (103)	3.10±0.01 (109)	3.33±0.01 (116)
6.	Plant growth rate	1.41±0.11	1.02±0.10 (100)	1.23±0.05 (120)	1.09±0.11 (106)	1.18±0.03 (115)	1.32±0.31 (129)

Values are an average of five observations. Values in parentheses indicate percentage activity over the control. Mean ± Standard Error.

Table-2: Effect of various adsorbents treated nickel on photosynthetic pigment of *P. americanum*.

S. No	Parameters	Control (Water)	Control (6mM NiCl ₂)	S1	S2	S3	S4
1.	Chlorophyll a (ug/gl fw)	0.291±0.1	0.215± 0.12 (100)	0.267±0.10 (124)	0.231±0.14 (107)	0.250±0.11 (116)	0.285±0.04 (136)
2.	Cholorophyll b (ug/gl fw)	1.313±0.13	1.050 ± 0.01 (100)	1.242±0.11 (119)	1.097±0.14 (105)	1.210±0.13 (116)	1.289±0.10 (124)
3.	Total chlorophyll (ug/gl fw)	1.664±0.1	1.255± 0.03 (100)	1.509±0.12 (120)	1.328±0.10 (106)	1.460±0.04 (116)	1.574±0.11 (125)
4.	Carotenoids (ug/gl fw)	1.90±0.01	1.31± 0.02 (100)	1.70±0.11 (129)	1.41±0.11 (108)	1.54±0.01 (118)	1.85±0.14 (141)

Values are an average of five observations. Values in parentheses indicate percentage activity over the control. Mean ± Standard Error.

Table-3: Effect of various adsorbents treated nickel on biochemical characters of *P. americanum*.

S. No	Parameters	Control (Water)	Control (6mM NiCl ₂)	S1	S2	S3	S4
1.	Glucose (ug/gl fw)	0.23±0.10	0.15± 0.12 (100)	0.18±0.10 (122)	0.16±0.14 (109)	0.17±0.11 (115)	0.19±0.04 (125)
2.	Protein (ug/gl fw)	1.62±±0.01	1.23± 0.01 (100)	1.48±0.11 (126)	1.33±0.14 (112)	1.40±0.13 (119)	1.52±0.10 (135)
3.	Amino acid (ug/gl fw)	2.03±0.04	2.47± 0.03 (100)	2.26±0.12 (87)	2.40±0.10 (95)	2.32±0.04 (92)	2.19±0.11 (79)
4.	Leaf Nitrate (ug/gl fw)	4.75±0.12	3.78± 0.02 (100)	4.38±0.11 (115)	3.93±0.11 (103)	4.25±0.01 (112)	4.59±0.14 (121)

Values are an average of five observations. Values in parentheses indicate percentage activity over the control. Mean ± Standard Error.

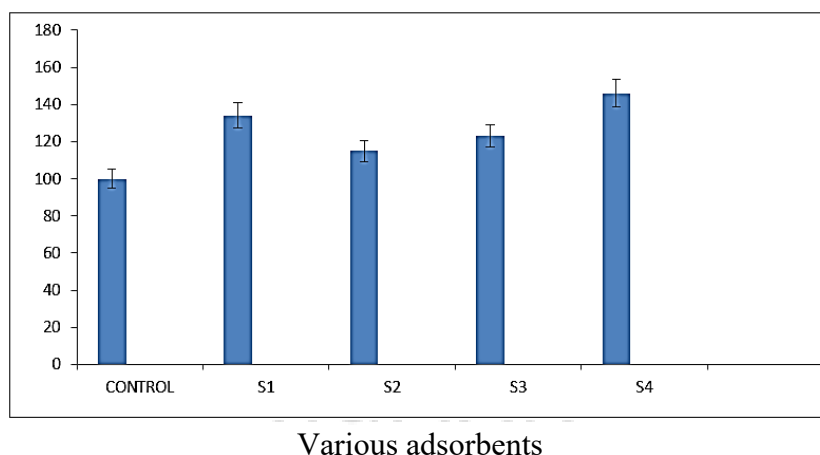


Fig-1: Bioadsorbents treated nickel chloride on chlorophyll 'a' on *P. americanum*.

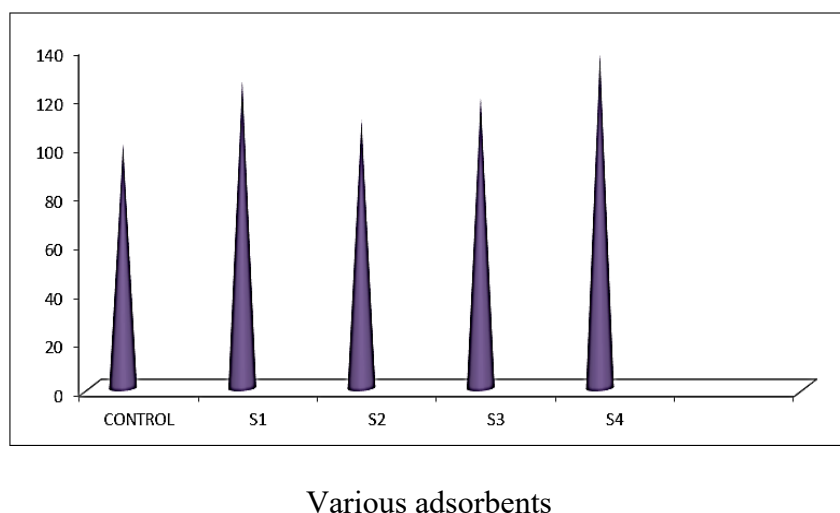


Fig-2: Bioadsorbents treated nickel chloride on chlorophyll 'b' on *P. americanum*.

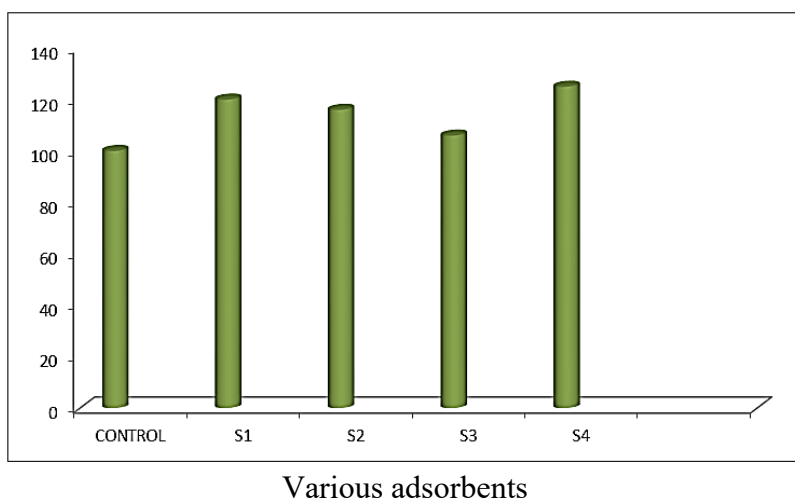


Fig-3: Bioadsorbents treated nickel chloride on total chlorophyll on *P. americanum*.

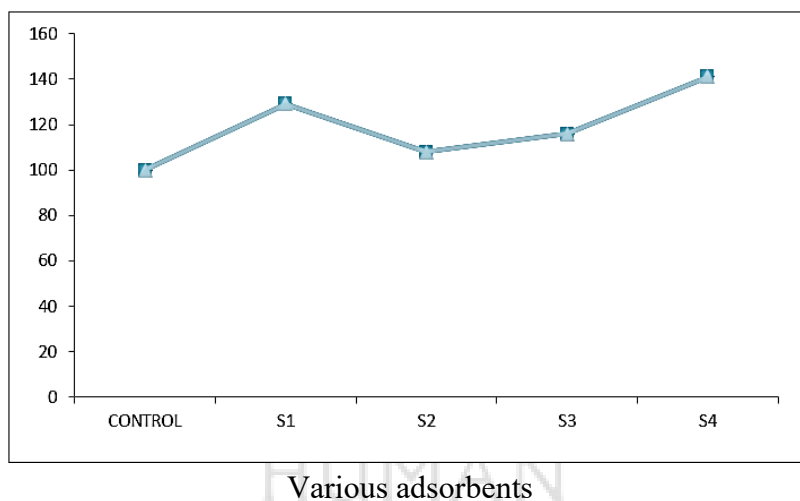


Fig-4: Bioadsorbents treated nickel chloride on carotenoids on *P. americanum*.

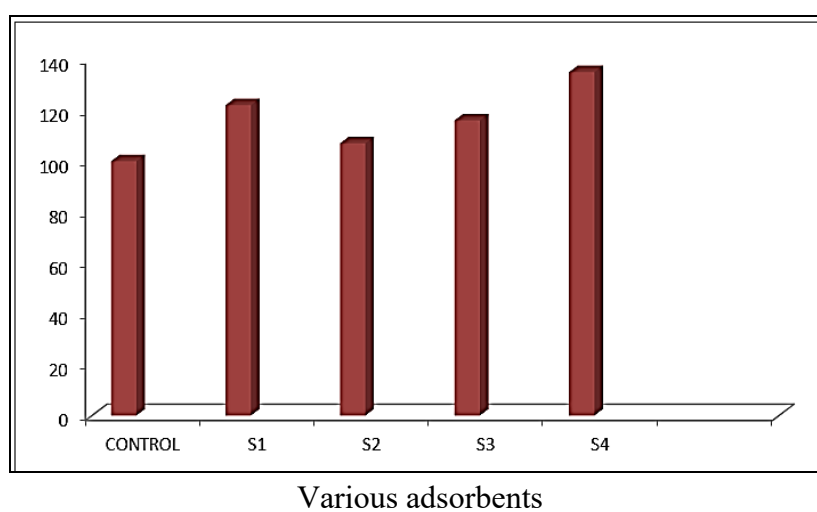
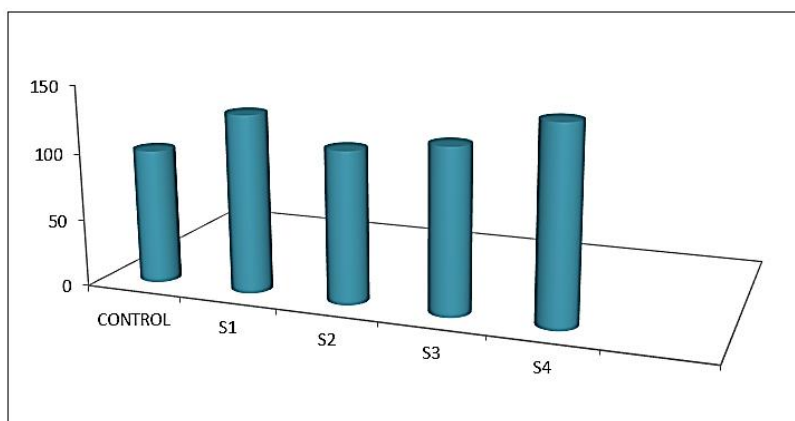
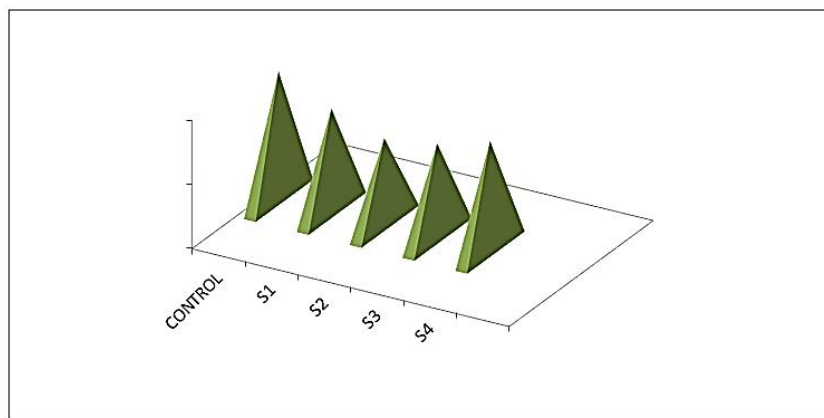


Fig-5: Bioadsorbents treated nickel chloride on catalase activity on *P. americanum*.



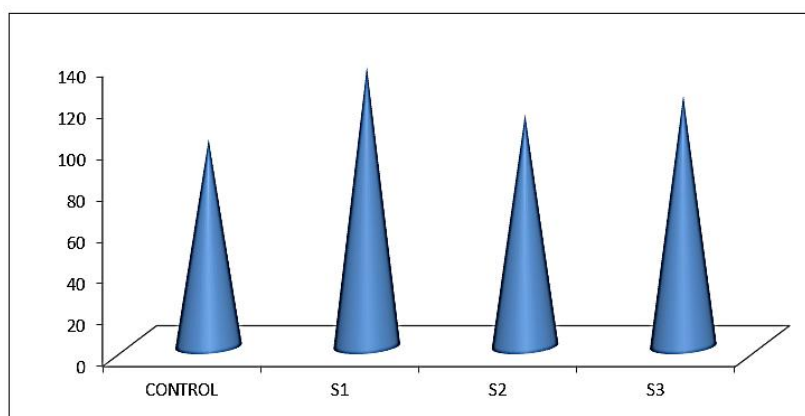
Various adsorbents

Fig-6: Bioadsorbents treated nickel chloride on peroxidase activity on *P. americanum*.



Various adsorbents

Fig-7: Bioadsorbents treated nickel chloride on nitrate reductase activity on *P. americanum*.



Various adsorbents

Fig-8: Bioadsorbents treated nickel chloride on superoxide dismutase activity on *P. americanum*.