ISSN:2395-1079

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South Asia Journal of Multidisciplinary Studies SAJMS June 2017, Vol. 3, No 5

UGC 49956-912

PHYTOREMEDIATION POTENTIAL OF SPIRODELA POLYRHIZA (GIANT DUCKWEED) FOR THE TREATMENT OF DOMESTIC WASTE WATER AT GWALIOR (M.P.)

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Abstract

Due to rapid population growth, increasing per capita water consumption, disposal of waste material in fresh water resources and geographical disparities between centers of population growth, by ecological degradation and availability of water, water scarcity became an issue to overcome the problem. Various technologies of wastewater management, which are simple, practical, economical, environmental friendly and capable of recycling or generating resources would be most desirable (Harrison 2002).

The different selected physicochemical parameters i.e. pH, Electric Conductance, Total Dissolved Solids, Total Suspended Solids, Total Solids, Chloride, Total Hardness, Ca hardness, Mg Hardness, Total Alkalinity, Nitrates, Phosphate & Potassium were analysed with standard protocol. Phytoremediation potential of Spirodela polyrhiza were assessed before and after treatment showed good capacity to remove pollutants from the aqueous solutions. Selected physico-chemical parameters other than Dissolved oxygen were decreases in all experimental setup at various concentrations. Among all the concentrations S. polyrhiza performed well at 100% & 75% of concentration and most of the parameters showed maximum reduction in the same concentration. Also, results revealed that application of industrial waste/effluent markedly improved the soil available potassium.

The present study still need further research to investigate the role of S. polyrhiza in detail with special reference to any effect on other living forms and its potential to remove toxic chemicals present in waste water.

Keywords: Phytoremediation, Ecological degradation, waste water management, pollutants.

Introduction

Water is essential for agriculture, industry and human existence. Water and its availability are important determinants of the human environment. Natural water resources such as rivers, lakes and streams contain sufficient factors responsible for growth of various organisms in the aquatic body (Dhasarathan et al., 2006). Water pollution is defined as unwanted and unnecessary substances that changes the physical, chemical and biological characteristics interfere with its use for legitimate purpose. Pollution has increased in major lakes, rivers, reservoirs of the world by various ways and there by posing threat to the survivability of the life system on these diverse water bodies (Meybeck et al., 1996).Water pollution is considered not only in terms of public health but also in terms of conservation, aesthetic and preservation of natural beauty and resources compared to air and land.

The earth's surface cover nearly 3/4th liquid water approximately 97% water lies in oceans as salt water, while 3% as fresh water,69% fresh water is locked up in ice caps and glaciers, 30% as ground water and0.3%

ISSN:2395-1079

Available online at http://www.gjms.co.in/index.php/sajms

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surface water i.e. swamps and lakes (USGS 2004). The impact involves gross changes in water quality including a number of parameters i.e. dissolved oxygen, pH, electrical conductivity, total solids, color turbidity taste etc. These changes have both short and long term consequences on aquatic ecosystem. Polluted drinking water containing chemicals could causes problem to health (Kumar 2013).

Remediation Technology with aquatic plants has a certain degree of purification. Plants with strong absorption of pollutants and good tolerance could be planted in the polluted water which accordingly removes or fixed water pollutants through adsorption, absorption, accumulation and degradation for water purification. As water pollution is growing continuously and various measures have been taken to overcome the problem for which various technologies have been employed. The removing of pollutants through the application of plants had gained importance and various plants have been proved to be efficient in waste water management. On seeing the potential of S. polyrhiza and phytoremediation and removal of pollutants from wastewater thus the present study was carried out to assess the impact of S.polyrhiza on domestic waste water.

Material & Methods

The present work on phytoremediation of pollutants from wastewater by Spirodela polyrhiza was carried out during 2016-2017 at School of Studies Botany Jiwaji University, Gwalior. The water sample was collected from Mahalgaon area and test plant (S. polyrhiza) from the pond near Captain Roop Singh Sports Hostel, Jiwaji University, Gwalior. S. polyrhiza (orth. var. S. polyrhiza) commonly known as duck meat, greater duckweed found nearly worldwide in many types of freshwater habitat. The Gwalior city is located at 26.22^0 North latitudes and 78.18^0 East longitudes, in the state of Madhya Pradesh with average elevation about 197 metres above msl.

The experiment was carried out as follows: Plastic tubs of 10 litre capacity, 15.24 cm depth and 35 cm in diameter were used for culturing of S. polyrhiza The test plants of S. polyrhiza were first washed thoroughly with tap water, followed by distilled water and then kept on filter paper to remove excess water. 25 grams of fresh biomass of S. polyrhiza with different concentrations of effluent i.e., 25%, 50%, 75%, 100% and control without effluent water. Five experimental set ups with 3 replicates each were prepared for waste water treatment. Following physico-chemical parameters i.e. pH, Electric Conductance, Total Dissolved Solids, Total Suspended Solids, Total Solids, Chloride, Total Hardness, Ca hardness, Mg Hardness, Total Alkalinity, Nitrates, Phosphate & Potassium were analysed in waste water with standard analytical methods of APHA. The analysis was carried out at initial (0 days) and after (15 days) interval of experiment in water samples for approximately two months. Results were computed on the basis of average of all three consecutive reading of each experimental setup (Table 1 & Graph 1 to 14).

Results

In S. polyrhiza maximum reduction in pH was found at 100% of concentration (6.72%) followed by 25% (3.92%), 75% (2.65%) and 50% (2.4%). On comparing the test plants with initial concentration maximum reduction of pH at 100% concentration and minimum reduction was observed at 50% concentration of experimental setup (Graph1). Electrical conductivity was reduced maximum in 100% concentration i.e. 52.50% followed by 50% concentration i.e. 44.49%, 75% concentration i.e. 29.96% and 25% concentration i.e. 23.21%

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respectively (Graph2). Dhingra et al., (2015) studied on physicochemical parameters of waste water effluents collected from industrial areas of Jaipur. It was found that pH values of effluents samples collected from dyes and textile industries showed extremely high total dissolved solid content.

After 45 days of culture /treatment reduction in total solids at different concentrations was observed. Maximum reduction in TS was found at 100% concentration i.e. 59.31% and minimum at 25% concentration i.e. 6.37% (Graph 3). Maximum reduction in total dissolved solids was found at 100% concentration i.e. 60.72% and minimum at 25% concentration i.e. 27.27% (Graph 4). Total suspended solids was also analysed and maximum reduction at 100% concentration i.e. 27.27% and minimum at 25% concentration i.e. 9.09% (Graph 5). Loveson et al., (2013) studied the aquatic macrophyte S. polyrrhiza as a phytoremediation tool in two polluted wetland water from Eloor, Ernakulam District, Kerala**.** The results showed the highest rates of reduction after 8 days of treatment for heavy metals, accounting 95%, 79%, and 66% for Lead, Copper and Zinc, respectively, followed by 53% for Chromium, 45% for Mercury, 26% for Cobalt, 20% for manganese and 7% for Nickel in wetland 1and physico-chemical parameters like pH, BOD, COD, Nitrate, Phosphate , sulphate, TDS, TSS and Turbidity were reduced by 12%, 37%, 49%, 100%, 36%, 16%, 53%,85% and 52% respectively. In wetland II heavy metals were removed with Cd (100%), Fe (98%), Pb (91%), Cu (74%) Zn (62%) and Hg (53%) removed more efficiently. Other physiochemical parameters like pH, BOD, COD, Nitrate, Phosphate , sulphate, TDS, TSS and Turbidity reduced by 14%, 40%, 60%, 100%, 38%, 65%, 73%, 85%, and 51% after 8 days of treatment.

The results of total hardness was observed after 45 days of culture, more reduction at 100% concentration i.e. 63.36% followed by 75% concentration i.e. 54.18.%, 50% concentration i.e. 46.31.% and minimum at 25% concentration i.e. 38.79% (Graph 6). Results for calcium hardness reduction was evaluated and it showed significant decrease in all concentrations with maximum reduction at 100% concentration i.e. 58.23% followed by 25% concentration i.e. 39.51%, 75% concentration i.e. 22.82% and minimum at 50% concentration i.e. 19.65% respectively (Graph 7). The results of Mg hardness was observed after 45 days of treatment, maximum reduction was observed at 100% concentration i.e. 66% followed by 75% concentration i.e. 64%, 50% concentration i.e. 56.31.% and minimum at 25% concentration i.e. 38% (Graph 8).

Maximum reduction in chloride at 100% concentration i.e. 81.82% followed by 75% concentration i.e. 78.46%, 50% concentration i.e. 69.57% and minimum at 25% concentration i.e. 41.67% respectively (Graph 9). After 45 days of culture (treatment) the results for alkalinity was evaluated and it showed significant decrease in different concentrations. The highest reduction of alkalinity was observed at 100% concentration i.e. 87% followed by 75% concentration i.e. 82%, 50% concentration i.e. 80% and minimum at 25% concentration i.e. 76% (Graph 10). The results of nitrate was evaluated and it showed significant decrease at different concentrations. The more reduction of nitrates was found at 100% (Graph 11).

DO is an important parameters in drinking water quality but in waste water concentration of DO is zero or negligible. Maximum increase in DO was found from 0 to 1.6mg/l at 100%. COD is important parameters in waste water analysis because it indicate requirement of oxygen concentration needed for degradation of complex organic pollutants to simple compounds. Maximum reduction in COD ranges from 95% to 97% in all experimental setup (Graph 12).

After 45 days of treatment the results for phosphates was evaluated and highest reduction ranges between 3.8mg/l, 4.4mg/l, 4mg/l and 3.2mg/l in 100%, 75%, 50% and 25% experimental set up respectively (Graph 13). Reduction of potassium was observed at 100% concentration i.e. 38.98% followed by 75% & 50% concentration i.e. 26% and minimum at 25% concentration i.e. 6.8% (Graph 14).

Discussion

Phytoremediation potential of S. polyrhiza in the removal of pollutants from the different concentrations of wastewater was studied by analyzing the wastewater before and after the treatment. The value before and after treatment with percentage changes were evaluated and were found that both the plants showed the good capacity to remove pollutants from the aqueous solutions. All the parameters other than Dissolved oxygen showed decrease /reduction at all concentrations. Among all the concentrations both the plants performed well at 100% & 75% of concentration and most of the parameters showed maximum reduction in the same concentration. Maximum reduction was found in phosphates and nitrates which revealed that the current test plants play a great role in removing organic waste from domestic sludge. Villa et al., (2016) studied to evaluate the efficiency of duckweeds Spirodela sp. and Lemna sp. in the treatment of tilapia effluents (Oreochromis niloticus). The results showed an efficiency in nutrient removal at 120 h of 75, 74 and 66% of N-NH_3; 96, 92 and 75% N-NO_2; 93, 88 and 75% N-NO_3; 75, 72 and 64% N-NTK; 73, 60 and 58% of N-org., and 73, 63 and 68% of P. The removal of TSS and BOD_5, during the first 24 h, was 83, 54, 58% and 65, 59, 33%, in the treatments respectively.

The above results depict that this treatment experiment is very efficient, cost effective, eco-friendly best alternative methods for domestic waste water treatment which convert complex organic matter into simple compound. Similar to constructed wetlands for wastewater treatment, reed bed technology uses plant uptake, in addition to evapo-transpiration, microbial decomposition, and drainage, to stabilize the quality of waste water. Ray et al., (2015) evaluated a study on arsenic and copper extraction capacity of Spirodela polyrhiza from water. The results showed that extraction capacity of S. polyrhiza was more than 80% for all concentrations of arsenic and more than 60% for all concentration of copper after 96 h. Wang et al. (2015) investigated the ability to fix carbon and energy in swine wastewater of duckweeds using S. polyrhiza. Chaudhuri et al., (2013) studied the cadmium removal by L. minor and S. polyrhiza. Experimental results showed that L. minor and S. polyrhiza were capable of removing 42–78% and 52–75% cadmium from media depending upon initial cadmium concentrations. Spirodela polyrhiza proved to be hyper accumulator of cadmium and L. minor was also found to remove cadmium effectively.

The prime objective of this study is to check and evaluate the best possible method for treatment of domestic waste water. The measures and efforts made in such a way to bring the pollutants present in waste water within the limits and to improve the environmental quality and maintain as for as possible the “Ecosystem Balance” by low cost, ecofriendly approaches.

The present study still need further research to investigate the role of plants in detail with special reference to any effect on other living forms and its potential to remove toxic chemicals present in our environment. According to Uggetti (2009) it is an effective process using plant life to help in the necessary process of treating some of the by products of human communities.

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Table:1 : Physico-chemical analysis of different concentration of experimental setup with S. polyrhiza

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S.No.	Parameters	Period	Experimental setup				
			Control	25%	50%	75%	100%
1	pH	0days	7.32	7.64	7.73	7.92	8.33
		15 days	7.30	7.59	7.68	7.87	8.25
		30 days	7.28	7.40	7.58	7.76	8.00
		45 days	7.26	7.34	7.54	7.71	7.77
2	EC (□S/cm³)	0days	686	896	1171	1399	1621
		15 days	680	820	1084	1205	1060
		30 days	615	795	1025	1060	1385
		45 days	589	767	1061	841	1240
3	TDS (mg/l)	0days	600	920	1340	1795	2160
		15 days	560	780	1100	1530	1860
		30 days	532	640	1030	1310	1582
		45 days	489	521	865	1095	1245
4	TSS (mg/l)	0days	60	63	68	80	89
		15 days	51	58	56	60	78
		30 days	48	49	46	52	60
		45 days	40	44	41	44	55
5	TS (mg/l)	0days	660	983	1408	1875	2249
		15 days	611	838	1156	1590	1938
		30 days	580	689	1076	1362	1642
		45 days	529	565	906	1139	1300
6	TH (mg/l)	0days	846	1706	2133	2506	2793
		15 days	802	1465	1952	2140	2260
		30 days	750	1280	1605	1820	2016
		45 days	669	1093	1246	1460	1826
7	CaH (mg/l)	0days	306	646	760	946	1050
		15 days	299	509	702	650	675
		30 days	310	455	532	560	626
		45 days	274	453	341	355	656
8	MgH (mg/l)	0days	540	1060	1373	1560	1743
		15 days	503	956	1250	1490	1585
		30 days	440	825	1073	1260	1390

		45 days	395	640	905	1105	1170
9	Nitrates (mg/l)	0days	3.50	4.20	6.20	8.80	10.20
		15 days	3.40	3.98	6.01	8.50	9.00
		30 days	2.86	3.20	5.70	8.10	8.70
		45 days	2.30	2.70	4.60	8.00	7.80
10	Chloride (mg/l)	0days	16.75	32.61	65.82	84.27	103.33
		15 days	15.25	28.10	57.11	76	90
		30 days	14.56	25.79	52.75	68.9	81
		45 days	14	24	46	65	77
11	Alkalinity (mg/l)	0days	120	643.33	823.33	944	1002
		15 days	109	560	709.17	857.9	920
		30 days	100	474	503	688.22	835.76
		45 days	88	366	450	503	675.09
12	DO (mg/l)	0days	9.50	2.20	1.40	0.90	0
		15 days	9.80	2.20	1.80	1	0.56
		30 days	8.70	3.15	2.76	1.61	1.02
		45 days	9.20	4.65	3.01	2.05	1.60
13	COD (mg/l)	0days	12.00	265	310	380	486
		15 days	11.50	252	298	368	462
		30 days	10.30	201	251	290	388
		45 days	8.30	190	180	227	272
14	Phosphates (ppm)	0days	4.16	4.52	5.98	6.45	7.50
		15 days	4.03	4.21	5.65	6.21	7.10
		30 days	3.88	3.97	4.72	5.62	5.40
		45 days	3.61	3.22	4.03	4.43	3.80
15	Potassium (ppm)	0days	22.00	28.00	31.76	35.87	39.7
		15 days	21.80	27.20	30.65	34.21	38.73
		30 days	20.50	24.40	28.54	30.11	36.50
		45 days	19.65	21.09	26.76	26.54	32.20

Note.: EC- Electrical conductivity, TDS-Total Dissolved Solids; TSS- TDS-Total Suspended Solids; TS-Total Solids; TH- Total hardness; CaH- Calcium hardness; MgH- Magnesium hardness;

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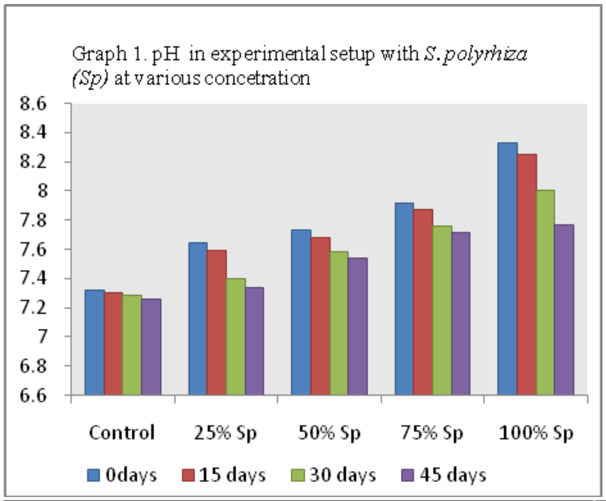

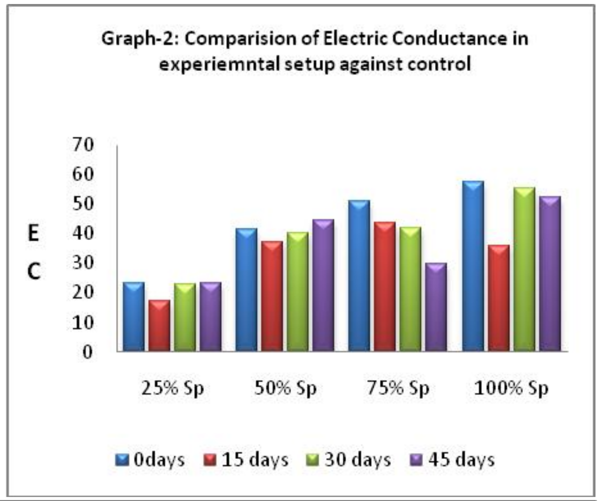

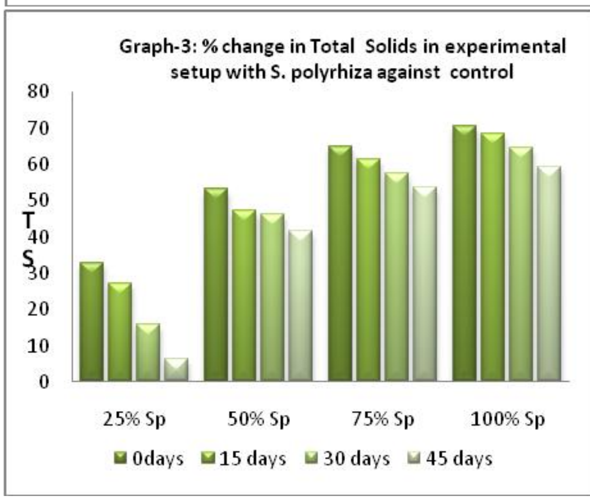

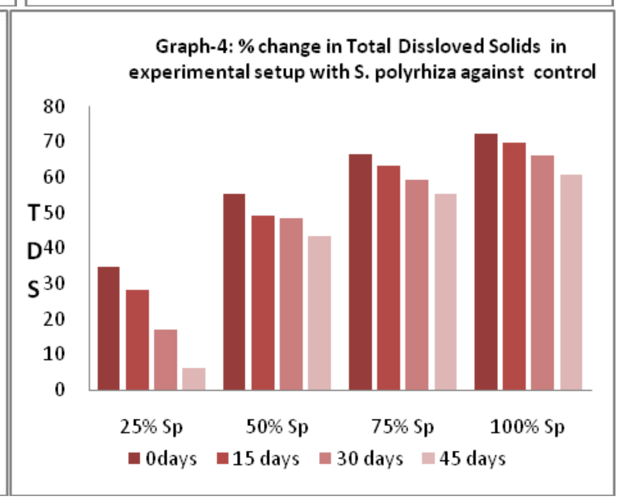

ISSN:2395-1079

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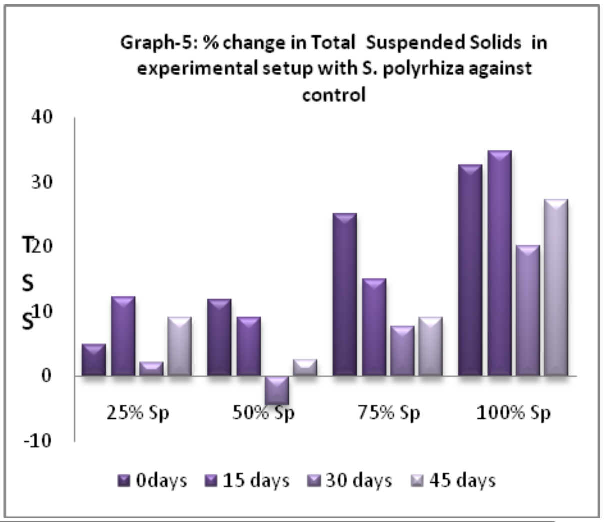
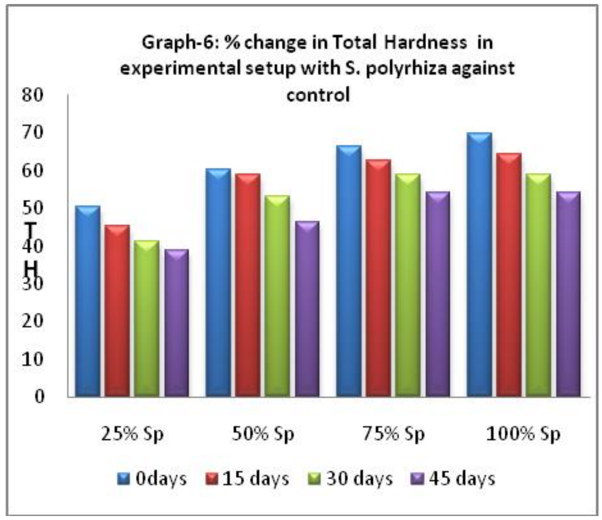
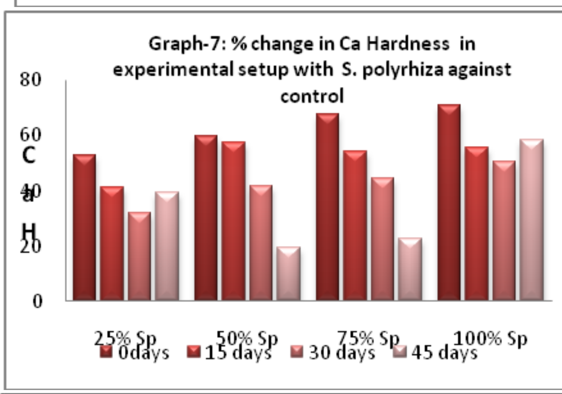
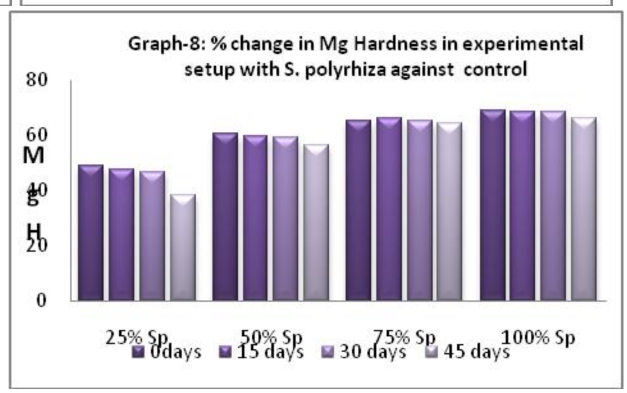
South Asia Journal of Multidisciplinary Studies SAJMS June 2017, Vol. 3, No 5

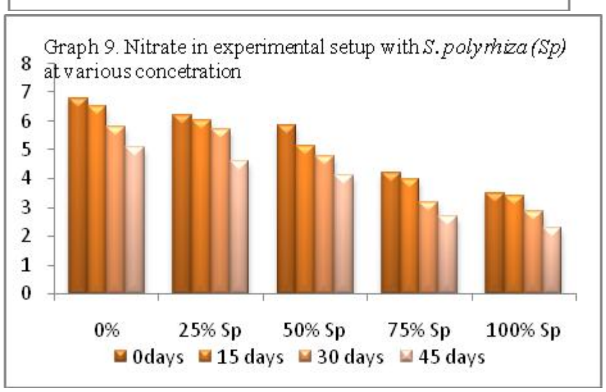
UGC 49956-912

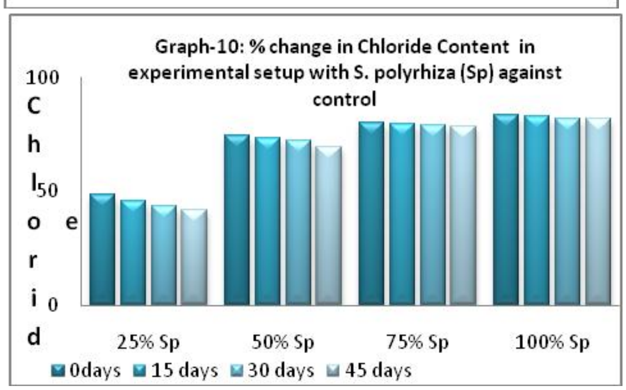












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