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EFFECT OF SECONDARY TREATED SEWAGE ON GROWTH AND PRODUCTIVITY OF HORDEUM VULGARE (BARLEY)

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ABSTRACT

Use of treated sewage for irrigation purposes has emerged an important way to utilize its nutrients and removal of its pollution load by growing tolerant species. In the present study, impact of secondary treated sewage has been studied on the growth, productivity and some physiological parameters of Hordeum vulgare. Secondary treated effluent was examined for its chemical constituents (pH, electrical conductivity, total suspended solids, total dissolved solids, dissolved oxygen, biological oxygen demand, chemical oxygen demand and phosphorus) and effects of its various dilutionson growth & productivity of barley was examined using pot experiments. Percentage of seed germination, root-shoot length, chlorophyll content and biomass estimation were studied. Full strength secondary treated sewage promotes the growth and productivity of Hordeum vulgare indicating the utility of secondary treated sewage as a potential source of water for seed germination and plant growth in agriculture practices.

Key words: *Secondary treated sewage, Seed germination, Root-shoot ratio, Total chlorophyll, Biomass estimation.*

INTRODUCTION

Sewage disposal is one of the major problems in India. In most of the cases the untreated sewage iseither discharged into nearby waterbodies or put into agriculture fields for irrigation (Girisha and Raju, 2008). Domestic sewage contains a wide variety of impurities and it is the primary source of pathogens (Vrushali and Kaustav, 2014). Sewage also comprises of micro-organisms such as bacteria, viruses and protozoans, which can be the principle source of water borne infectious disease (Sharma and Kaur, 2011). Sewage disposal is considered as one of the important sources of water pollution. The negative impacts of these effluents to aquatic ecosystem and to the people have been documented both at national and international levels. Some of these impacts can consist of loss of aquatic life, algal bloomand habitat destruction from sedimentation, debris, multiple water flow and other short or long term toxicity from chemical contaminants in aggregate with chemical accumulation and magnification at higher tiers of the food chain (Canada gazette, 2010).

Sewage wastes also contains considerable amount of harmful substances together with soluble salt and heavy metals. Plants can accumulate heavy metals in their tissue in concentration above the permissible levels which is a threat to the life of human, and animals feeding on these and may lead to contamination of food chain (Adnan, 2010).

The United Nation General Assembly in the year 2000 adopted the millennium development goals (MDGs), which is most directly related to the safe use and discharge of wastewater. Eight MDG goals ensure environmental sustainability. In order to maximise the health and environmental benefits associated with the use and discharge of the waste water, several legislations and guidelines have been developed both at national and international levels. The World Health Organisation (WHO) guidelines for the reuse of the effluents were developed in 1973, whichwas subsequently revised in 1989 and 2006 (WHO, 2006). Sewage wastes are quite rich in organic matter and serves as plant nutrients suitable for agriculture application thus increases crop yield significantly and reduce the need for fertilizers and in turn reduces average price of production (Nath *et al*., 2009; Kumar, 2014). When the sewage wastes is applied in agriculture field, it benefits the physical characteristics of the soil, which includes the formation of aggregates of soil debris, which in turn increase the size of empty spaces, water retention and also enabling an extra capacity of aeration (Lee, 2011). The reuse of waste water in agriculture is gaining wider recognition in many parts of the world. It represents an agronomic alternative that is being investigated and taken up in area with water scarcity, developing urban populations, and rising demand for irrigation water. Many irrigated regions around the world are experiencing water shortage due to numerous factors, consisting of climate change (precipitation), surface and ground water pollution. Water shortage poses serious economic, social and even political issues in all of its factors. Under these circumstances treated waste water use can help to mitigate the harmful outcomes of local water deficits (FAO, 2011). Treated wastewater not only offers an alternative water irrigation source but additionally the opportunity to recycle plant nutrients. Treated wastewater can be a source of pathogenic organisms and potentially hazardous chemical materials like enteric microorganism, andviruses, salt, heavy metals, and surfactants. Those may then gather in the soil, with destructive results on crop quality and productivity, and also on the ecological soil condition (Chen *et al*., 2008). Recycled wastewater effluent is considered as an essential source of irrigation in arid and semi-arid areas. Reuse of wastewater should be deliberated better in the dusting as the sewage flow is growing every day. Because

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of the high nutrients contents, farmers are benefited with high yield at the sewage water irrigation with much less fertilizer input (Patel*et al.,* 2007; Kamboj *et al.,* 2016). According to the Tak *et al.,* (2013), four types of crops were irrigated with the waste watercan be ascribed to the ordinary supply of mineral nutrients to the Rhizosphere. The study concluded that except Hg and Cd, irrigated plots content most heavy metal contents than the controlled plots and low salinity level but SAR and ESP values were high with one recovered case of *E.coil.* Thus, keeping in view of the above facts, the present study was conducted to assess the physico-chemical and biological characteristics of secondary treated sewage collected from sewage treatment plant at Jagjeetpur Village (Haridwar, Uttarakhand) and its impact on plant growth and productivity of *Hordeum vulgare.*

MATERIALS AND METHODS

Sample Collection

The sewage samples were collected from sewage treatment plant at Jagjeetpur (Haridwar) in clean plastic bottles and brought to the laboratory in sampling kits maintained at 4^{o}C. The soil samples were collected fromthe garden of Gurukul Kangri Vishwavidyalaya in clean polythene bags.

Plate Experiments

Ten seeds of *Hordeum vulgare*were sterilized with 0.1% $HgCl_2$ for 2 minute and washed with distilled water. Experiments were performed by using different concentrations (25, 50, 75 and 100%) of treated sewage and poured in petri-plates containing 10 seeds of *Hordeum vulgare*.

Pot Experiments

Twenty seeds of *Hordeumvulgare* were sown in different pot. The seeds were washed with distilled water and irrigated with different concentration of treated sewage (25, 50, 75 and 100%).

Analysis of Treated Sewage

The secondary treated sewage was analysed for its physico-chemical and biological characteristics as per standard methods (APHA, 2016; Trivedy and Goel, 1998).

Soil Analysis

The physic-chemical parameters of the soil sample, viz., temperature, pH, electrical conductivity, moisture content, organic matter and phosphorus were also determined as per standard methods (Trivedy and Goel, 1998).

Plant Parameter

Percentage of seed germination, root-shoot ratio, chlorophyll content, biomass estimation were studied.

RESULTS AND DISCUSSION

The present study was undertaken to see the effects of secondary treated sewage on the growth and productivity of *Hordeum vulgare.* P hysico-chemical and biological characteristics of secondary treated sewage and soil samples are given in Tables 1 and 2 respectively while the effect of secondary treated sewage on growth parameters of *Hordeum vulgare* (barley) are given in Table 3 and described in the following sections.

Characterization of Sewage Waste

Temperature: Temperature is one of the most important factors as it affects the chemical and biological reaction of the organisms in the water. At elevated temperature metabolic activity of organism's increases, requiring more oxygen but at the same time the solubility of oxygen decreases (Trivedi and Goel 1990). In present study, temperature of secondary treated sewage effluent was recorded as 19.56±0.5. There is an increase in the temperature during the study from January to March, which may be due to increase in ambient air temperature. As theair temperature increases it affects the waste water temperature and waste water temperature increases accordingly.

pH: pH is one of the important parameters as it influences many biological and chemical processes within the water body (Chapman 1996). pH is the measure of intensity of acidity and alkalinity and also measure the concentration of hydrogen ion in water. The pH value of the secondary treated sewage was recorded 7.44±01.The factors like air temperature bring about changes in pH of water. Most of bio-chemical and chemical reactions are influenced by pH. The similar trend of pH in secondary treated effluent was observed by Lakhiwal *et al*. (2015).

Electrical Conductivity (EC): Electrical conductivity is numerical expression of the water ability to conduct an electric current. Electrolytes in a solution dissociates into positive and negative ion which impart conductivity. In present study, the recorded conductivity value of secondary treated sewage effluent was 593±0.01 µS/cm. Increasing in the EC was due to various dissolved organic and inorganic substances in sewage which increase the electrolytes content with the consequent increase in electrical conductivity.

Total Dissolved Solids (TDS): Dissolved solids refer to any minerals, salts, metals, cations, anions dissolved in water. Total dissolved solids can be determined as the residue left after evaporation and impart unfiltered sample. Total dissolved solids do not contain any gas and colloids. In present study, the recorded TDS value of secondary treated sewage effluent is 381.5± 8.6mg/l.

Total Suspended Solids (TSS): TSS of a water or waste water sample is determined by pouring a carefully measured volume of water sample through a pre-weighed filter paper of a specified size then weighing the filter again after drying to remove all water sample. Total suspended solids impart turbidity to the water or waste water. In present study, the TSS of secondary treated sewage effluent was recorded 230±9.7 mg/L. The similar trend of TSS in sewage treatment plant was observed by Salman (2017).

Dissolved Oxygen (DO): Dissolved oxygen is one of the most important characteristics in water quality assessment and reflects physical and biological process prevailing in to water, its presence is essential to maintain the high form of biological life in water. The solubility of DO increases with decrease in the water temperature. In present study, the observed mean value of dissolved oxygen of secondary treated sewage effluent was recorded 5.29±0.25 mg/L. The similar value of DO in treated sewage effluent was observed by Lakhiwal *et al*. (2015). During the study period dissolved oxygen decrease in treated waste water because the temperature of waste water was increasing from January to March. The higher temperature decreased the solubility of oxygen in the water. The dissolved oxygen was increased in the treated water because of aeration.

Biochemical Oxygen Demand (BOD): BOD is the measure of oxygen required to oxidize the desirable organic matter in water sample and can be defined as the amount of oxygen required by microorganisms present in the water during the stabilization of organic matter under the aerobic condition. In present study, the BOD of secondary treated sewage effluent was recorded 6.6±0.22 mg/L. The reduction in BOD depends on the aeration provided because the microorganisms use oxygen for the breakdown of organic matter which imparts BOD to the water. In this study, the BOD was decreased to a great extent because of proper oxygenation. Similar results in BOD before and after treatment were observed by Bhutiani *et al.* (2016) and Prachi *et al.* (2014).

Table1. Physico-chemical and Biological Characteristics of Secondary Treated Sewage

S. No.	Parameters	Mean Values*
1.	Temperature (°C)	19.56 ± 0.50
2.	pH	7.44± 0.10
3.	Electrical Conductivity (µs/cm)	593 .0±0.01
4.	Total Suspended Solids (mg/L)	230±9.70
5.	Total Dissolved Solids (mg/L)	382±8.60
6.	Dissolved Oxygen (mg/L)	5.29±0.25
7.	Biochemical Oxygen Demand (mg/L)	6.6± 0.22
8.	Chemical Oxygen Demand (mg/L)	25.28±0.56
9.	Phosphorus (mg/L)	0.402 ± 0.02
10.	Most Probable Number (MPN)/100mL	220

*Values are mean ± SE of 7 observation each.

Chemical Oxygen Demand (COD): COD is a measure of oxygen required by the organic substance of water to oxidize them by a strong chemical oxidant. In present study, the recorded COD value of secondary treated sewage effluent was 25.28±0.56 mg/L. Significant reduction was observed in COD in treated water because of proper oxygenation. Microorganisms utilise to oxygen which was provided by the aeration to degrade the chemical matter present in the waste water thus reduced the COD. Similar value of results in COD sewage treatment plant was observed by Kulkarni *et al*. (2016) and Bhutiani *et al*. (2016).

Phosphorus: It plays a fundamental role in the very large number of enzymic reactions that depends on phosphorylation. It is an essential component of organic matter compound. In the present study, the recorded value of phosphorus was 0.402±0.02mg/L. The removal of phosphorus from waste water involves the incorporation of phosphate into TSS and subsequent removal from these solids.

Characterization of Garden Soil

Temperature: Soil temperature is measured using a thermometer. The bulb of the thermometer was kept outside of metal cone to facilitate the penetration into the soil. The soil thermometer is an important instrument to study the soil temperature. Soil temperature affect the soil properties. During the present study, the recorded value of soil temperature was 21.3±0.04 (Table 2).

Soil pH: pH of soil is a measure of the hydrogen ion activity which depend largely on relative amount of absorbed hydrogen and metallic ion. It is also affected by temperature as well as moisture content of soil. In present study, the soil pH was recorded 7.07±0.01. It has been observed that soil pH increases during the winter season while decreases during summer season. This decrease may be during CO_2 and organic matter produced during microbial metabolism (Edward and Boglen, 1996).

Table 2. Physico-chemical Characteristics of Soil Samples

S. No.	Parameter	Mean Values*
1.	Temperature (°C)	21.3±0.04
2.	pH	7.07±0.01
3.	Conductivity (µS/cm)	0.0115±0.00
4.	Moisture Content (%)	3.73±0.16
5.	Organic Matter (%)	1.54±0.01
6.	Organic Carbon (%)	0.598±0.02
7.	Phosphate (mg/L)	0.37±0.001

*Values are mean ± SE of 3 observation each.

Table 3. Effects of Secondary Treated Sewage on the Growth Parameters of *Hordeum vulgare* (barley)

S.No.	Plant Parameters	Control	Percentage of Secondary Treated Sewage			
			25%	50%	75%	100%
1.	% Germination	70%	75%	75.56%	80%	80%
2.	Root length (cm)	2.7±0.1	3.4±0.5	3.23±0.2	3.55±0.5	4.66±0.6
3.	Shoot length (cm)	11.5±0.80	12.2±0.88	12.63±0.66	12.93±0.72	14.42±0.47
4.	Total chlorophyllcontent(mg/g)	5.67±0.05	5.57±01	6.11±0.16	6.45±0.1	6.72±0.12
5.	Chlorophyll ‘a’(mg/g)	3.2±0.01	4.27±0.04	4.31±0.09	4.55±0.06	4.67±0.06
6.	Chlorophyll ‘b’(mg/g)	1.35±0.04	1.37±0.06	1.18±0.07	1.59±0.04	2.17±0.17
7.	Fresh biomass (gm)	118.3	171.0	176.2	190.0	220.0
8.	Dry biomass(gm)	15.6	15.2	20.0	25.0	27.0

Soil Conductivity: Soil conductivity is related to the soluble salts which are present to some extent in all soil. In the present study, the recorded value of soil conductivity was 0.0115±0.00 μS/cm (Table 2).

Moisture Content: Moisture content refers to the water held by the individual particle of the soil sample. Water present in the soil act as solvent and transporting agent. It contains texture and compactness of soil. It is important for maintaining habitat of plant and animals. In the present study, the recorded value of moisture content was 3.73±0.16 % (Table 2).

Organic Matter: Organic matter has an important role to play in maintaining soil structure, nutrient availability and water holding capacity. In present study, the recorded value of soil organic matter was 1.45±0.02 (Table 2).

Phosphorous: Phosphorus play a fundamental role in the very large number of enzymic reactions that depends on phosphorylation. It is an essential component of organic matter compound. In the present study, the recorded value of phosphorus was 0.37±0.001 (Table 2).

Effect of Secondary Treated Sewage on Growth and Productivity of *Hordeum Vulgare*

Effect of secondary treated effluent on test crop *Hordeum vulgare (barley)* was assessed by observing various plant parameters like % seed germination, root length, shoot length, chlorophyll content, fresh and dry biomass (Table3). The pot experiment for assess the plant growth in different concentration effluent seen in Fig. 1.

During the present study, the plant was irrigated with four different concentration of sewage water such as 25 %, 50%, 75% and 100%. The result shows that all the plant parameters, such as seed germination, root length, shoot length, chlorophyll content, fresh and dry biomass were reported maximum in 100% concentration while minimum were recorded in control depicted in Table 1. The maximum value of seed germination, root length, shoot length, chlorophyll content, fresh and dry biomass in 100% concentration was due to the presence of macro and micronutrients such as potassium, phosphorus and nitrogen in the treated effluent.

Fig. 1. Effect of Different Concentrationsof Secondary Treated Sewage On *Hordeum vulgare* under *in-vivo* condition

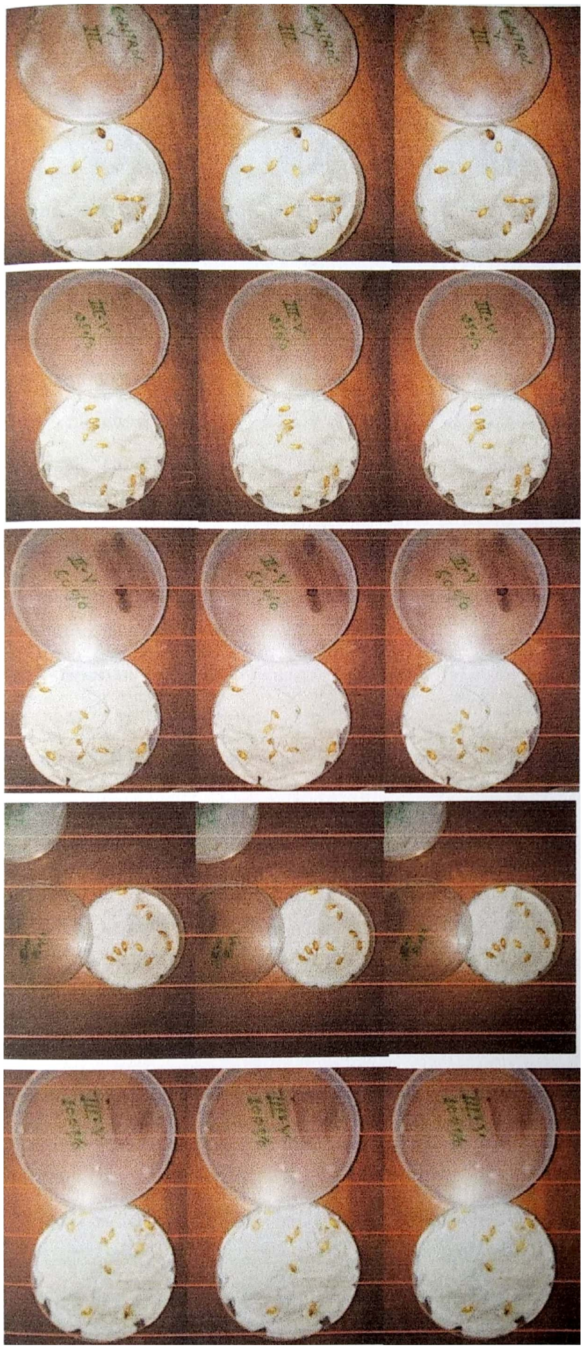

Fig. 2. Effect of Different Concentrations of Secondary Treated Sewage On *Hordeum vulgare* under *in-vitro* condition

CONCLUSION

Use of treated sewage for irrigation purposes has emerged an important way to utilize its nutrients and removal of its pollution load by growing tolerant species. It is also an effective means for conservation of fresh water, because the treated water can be successfully used in different types of activities such as floor washing, irrigation and gardening in place of fresh water. The present study was performed to analyse the secondary treated sewage and its impacts on the growth and productivity of *Hordeum vulgare* (barley). The results obtained during the study indicate that the secondary treated sewage can be successfully utilized for irrigation /agriculture practices. Germination efficiency, root-shoot ratio, total chlorophyll content and biomass estimation was found to increase with the increase in concentration of secondary treated sewage.

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