Phytoremediation of kerosene contaminated water by using plant *Typha domingensis*

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Abstract:

Water pollution with hydrocarbons is a serious environmental problem in Basrah. Kerosene is one of the many pollutants solubility and common in the aquatic environment due to the multiple uses of. *Typha domingensis* was used to treat kerosene-contaminated water in the construction wetland system for 72 days and compare it to other treatment such as *Typha domingensis* with bacteria, and hydrocarbon degrading bacteria. The rate of hydrocarbons removal from the water contaminated with kerosene in the ponds of the plant without bacteria and plant with bacteria، bacteria only and control (76.5) %, (81.9)%, (74.1) %, (57.4) % respectively. The accumulation of hydrocarbon in plants with bacteria and without bacteria was (184.5), (181.7) µg / g respectively. Recorded during the study, a decrease in pH and dissolved oxygen and biological oxygen demanded (BOD_5) and increase temperature. Thus addition bacteria to plant increase the performance of phytoremediation technology for water treatment.

Keywords: phytoremediation, kerosene, hydrocarbon removal, Typha domingensis

Introduction:

Hydrocarbons are common and naturally occur in the environment, and varying concentrations in storm water and effluent water are not unusual (Cai et al. 2010). The types of industries discharging waste to rivers and lakes represent a wide range of industrial quality and these resulting environmental effect or risk from these effluents is varied (Botalova et al. 2009). Industrial wastewaters tend to contain a huge load of organic and inorganic pollutants. Therefore, the oil and its derivatives were introduced to the environment, especially the water environment for frequent transport accidents (Kvenvolden and Cooper, 2003). The oil refineries are one of the sources of water pollution because of the liquid wastes that are presented in the form of ammonia, sulfate, hydrocarbons and phenols. These components differ from one refinery to another, in addition to the differences in their toxicity. The main hydrocarbons contaminants in crude oil, aliphatic and poly aromatic hydrocarbon (Wake, 2005). Kerosene Liquid fuel is similar in its composition to diesel and is made up of 68.8% of straight canines. The number of carbon atoms in kerosene ranges between C16 - C9, characterized by low kerosene evaporation rate, the solubility of kerosene 5-12 mg/l (Chilcott et al. 2006).construction wetland consists of ponds containing porous components. The engineering structure of this system helps control the direction of the water flow and the period of time in which the water remains in the ponds in addition to controlling the water level (EPA, 2000). The removal of contaminants in construction wetlands occurs during many complex processes, including physical, chemical and biological processes (Faulwatter et al., 2009).The process of removing organic pollutants occurs during the process of biodegradation by the bacteria in rhizosphere and physical processes in an aerobic, anoxic and anaerobic zones. The aerobic confined to the root area that leaks oxygen to the base material. Factors affecting the rate of removal of organic matter in construction wetlands include temperature, pH, oxygen, pollutant concentration, and nutrient availability (Vymazal, 2010). Wetland plants play a major role in the retention of pollutants and their removal from wastewater and have a physical effect in the treatment process by stabilizing the substrate and have root system that filters the solid materials and provides a surface area for the growth of microorganisms (Herath and Vithanage, 2015). Phytoremediation are used for the treatment of wastewater, which performs the degradation, conversion, metabolism and removal of the toxicity of contaminants (Al-

Baldawi et al. 2013). Phytoremediation of hydrocarbons depends primarily on the root zone, which involves the breakdown of pollutants in soil as a result of microbial activity (Rohrbacher and St-Arnaud, 2016).

Material and method

Experimental design of construction wetland (CW_S)

This experiment was conducted at the environmental treatments station at collage Science, University of Basra, which focused on the use of southern cattail Typha domingensis in a Phytotoxicity test to treat water contaminated with a certain concentration of kerosene which was used depending on the results of the preliminary test. Glass basins were used to reduce or to prevent the adhesion of kerosene to the walls of the ponds with dimensions 30 cm * 30 cm. The basins was filled from the bottom to the top sequentially with a layer of medium gravel (Φ10-20mm) 8cm deep; a layer of fine gravel (Φ1-5mm) 3 cm deep, and a layer of fine sand (Φ2mm) 10 cm deep. Nine basins were prepared, two of this was planted with *T. domingensis* and two basin with same characters but with addition bacteria. Another two basin addition only bacteria without plant ,put two basin contain water contaminant only as a control and one basin planted with *T. domingensis* in tap water without contaminant .The basin planted with ten plant. Synthetic wastewater was prepared by mixing kerosene with water in concentration 5% ($V_{water}/V_{kerosene}$). All the CWs were operated batchwise with 8 L o contaminant water.

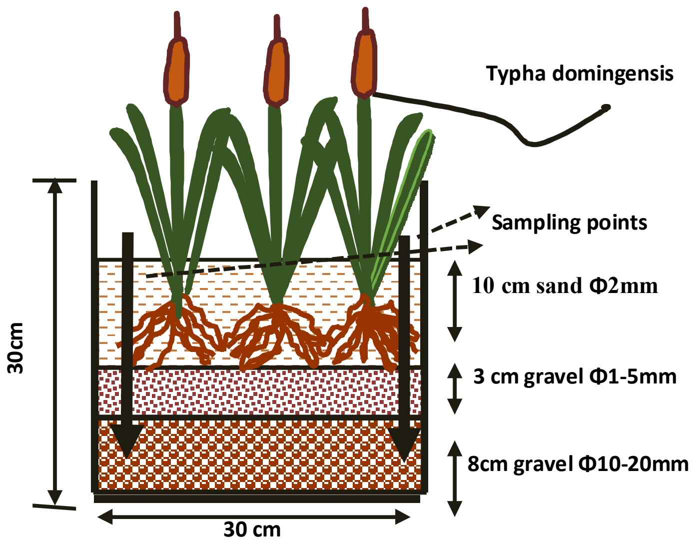

Figure 1: Diagram of an aquarium for the sub-surface flow system

Monitoring of water parameters

In phytotoxicity test water sampling collect from all basin deep 5cm from button of basin, The physicochemical parameters of the wastewater, including temperature (WC), pH, dissolved oxygen (DO) (mg/L), biological oxygen demand (BOD) (mg/L) were recorded to observe the physicochemical changes in the wastewater. Temperature, pH, BOD were assayed by Ph meter model 3310 German (WTW), Water quality Multimeter Senso Direct 150 (Lovibond), BOD tester German (WTW).

Effect of kerosene on plant growth

Plants were taken from plant treatment basin and control basin with time intervals divided into (0, 7, 14, 28, 42, 72) day .The plant is washed with tap water well, to removal sand from it . The stem length and root length, wet weight of each plant is measured and then placed in the oven at a temperature 70 c° for 72h until proven weight to measured dry weight (Al-Baldawi et al. 2013).

Count the numbers of bacteria in the root

To study the effect of kerosene on bacteria population ,take (10) g of the root and put in

100 ml of sterile normal saline. This was shaken at 150 rpm for 1h to release adhered microorganisms. After transferring 1–9 mL of sterile saline water, subsequent dilutions up to 10^{-4} were made. Next, 0.1 mL of the three (10^{-2}, 10^{-3} and 10^{-4}) dilutions was spread onto sterile plates containing a nutrient agar medium. (Peng et al., 2009; Moreira et al., 2011).

TPH analysis in water

To determine the TPH content in water, 100 mL of water collect from basin; the samples were extracted according to (Chaillan et al. 2004). The method was conducted by extracting samples with chloroform 1:1 .After extract ,put sampling in Hood to evaporation then addition 2-3 ml hexane to sample for measure in Spectrofluorometer .TPH removal on each sampling day was determined using Equation

$$\%Removal = \frac{TPH_0\text{-}TPHt}{TPH_0} \times 100$$

Where TPH_0 = total petroleum hydrocarbon on sampling day 0

TPH_t = total petroleum hydrocarbon on each sampling day.

Total petroleum hydrocarbon analysis in plants

To determine uptake total petroleum hydrocarbon by *T. domingensis*, take 1g plant dried at 70℃ for 72 h and put in thimble, then put in Soxhlet after addition 1:1 0f Methanol: Benzene for 24 h. The TPH extracts put in vial and evaporated ,after that addition 2ml of solvent to measure in Spectrofluorometer (Grimalt and Oliver,1993).

Statistical analyses

Data were analysed with the statistical IBM SPSS Statistics 24. Differences between treatments and different samples were analysed by two-way ANOVA ($p<0.05$) according to the Duncan multiple range test Statistical analyses.

Results and discussion

Monitoring of water parameters

In the Phytotoxicity test, recorded physicochemical parameters of water. In general, pH, BOD and DO decreased during the exposure period. The temperature increase through 72 day. The temperature depended on weather and ranged between (21.1 – 36.3) c̊, this temperature optimum to biodegradation (Pan *et al*. 2012).

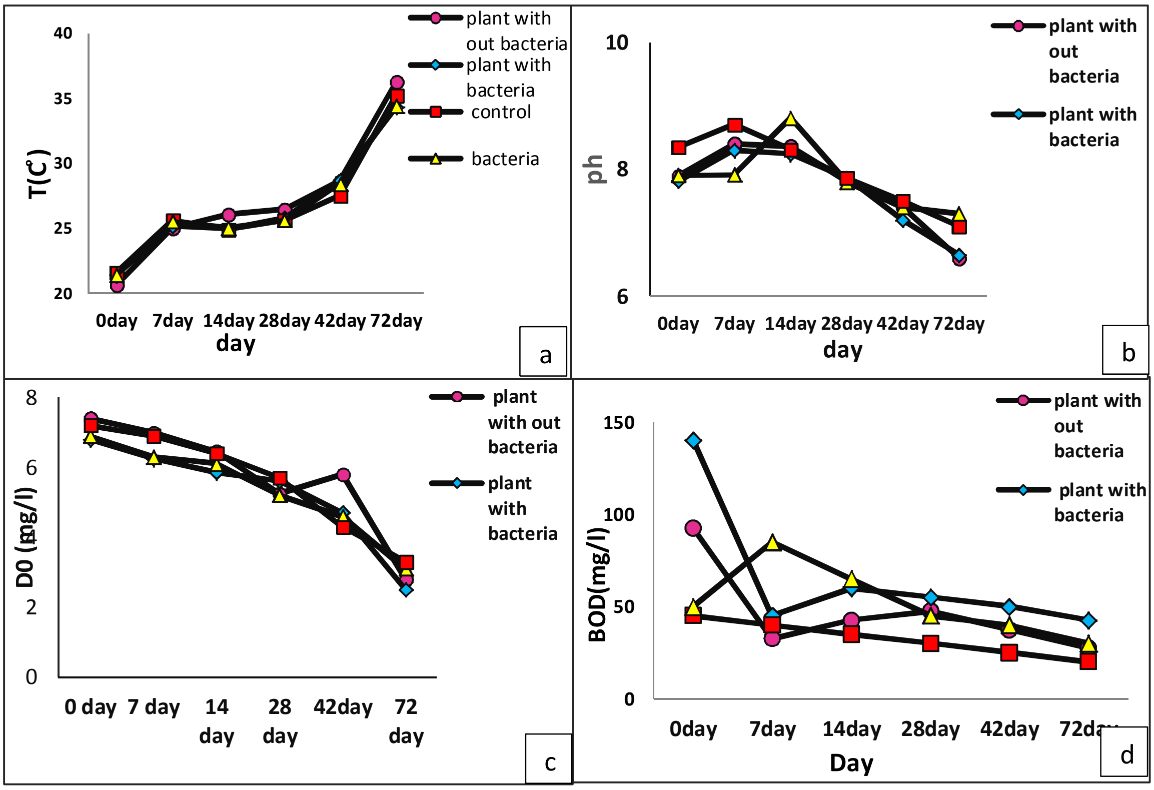

Figure 2: Physical parameter variations along phytotoxicity test with *T. domingensis* 5%in kerosene: (a) Temperature, (b) pH, (c) Dissolve oxygen and (d) biological oxygen demand (Bod).

The ph in basin contain plant with and without bacteria ,bacteria and control ranged between{ (8.2-6.65) (8.4-6.6) (8.8-7.3) (8.7-7.1)} respectively. It is possible that acidic ph condition result by consumption CO_2 by plant and algae (IMRP, 2006) and activity of microorganism in biodegradation TPH (Lohi *et al*, 2008, Sepahi *et al*., 2008).through 72 day conversation aerobic condition to anaerobic .DO decrease from 7.4 to 2.5 mg/l result increase temperature(r=-0.927) (p<0.01)

(Mustapha, 2018) .BOD decrease in basin from 140- 20 mg/L as show in (figure.2).

Plant response to kerosene contaminant

The selected plant growth parameters were determined and recorded on each sampling day during the 72 days test .The plant in treatment basin and control increase through 42 after that plant withered in treatment basin. the wet weight ,dry weight ,stem length a nd root length of *T. domingensis* without bacteria (67-110)g, (10.3-31)g , (40.5-75)cm, (14.5-6.1) cm respectively and *T. domingensis* with bacteria (47-137)g, (6.9-27)g, (42.5-74.5) cm, (6.75-15.5)cm.

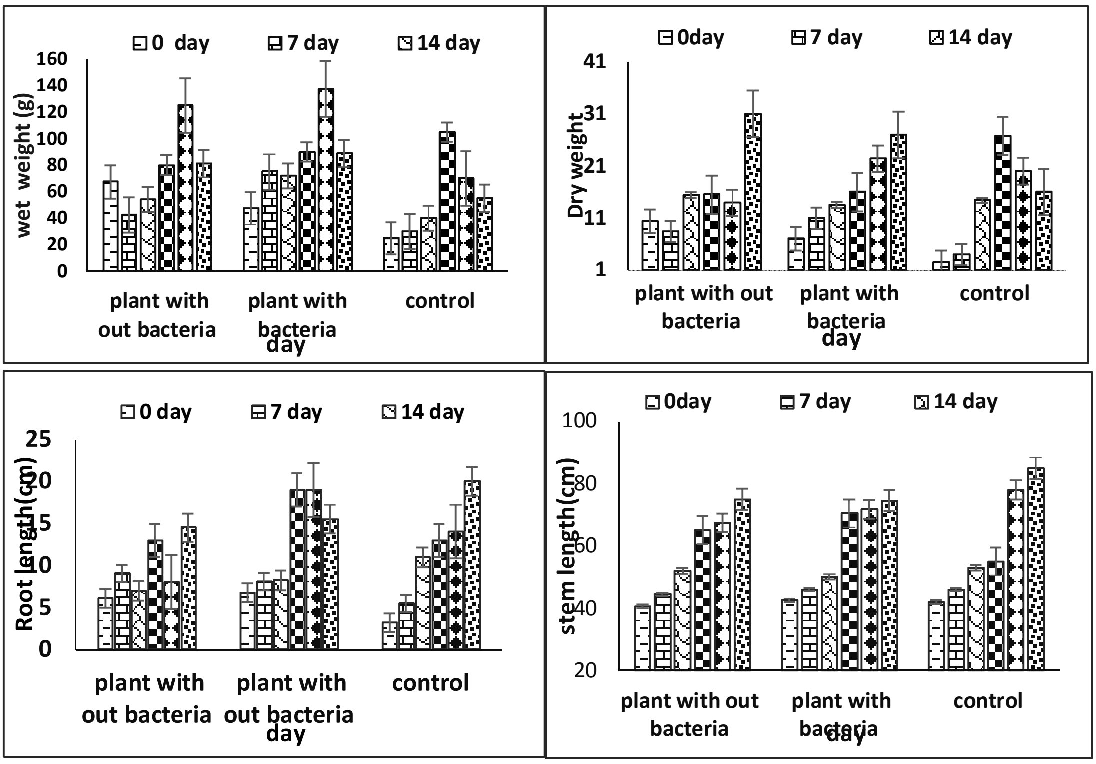

Figure 3: Growth response parameters of wet and dry weight, root length and stem length, in the phytotoxicity test of *T. domingensis* with 5% kerosene

The wet weight, stem height and root length of Typha domingensis in construction wetland with bacteria were significantly different ($p<0.05$) than those in the construction wetland without the addition of bacteria, This is because the addition of bacteria to the plants in the treatment basin has reduced the effect of hydrocarbons that pass through the plant's membranes and lead to toxic effects. In addition, hydrocarbons are considered to be hydrophobic compounds and thus form a barrier to prevent the transfer of water necessary for a plant. The addition of bacteria has helped the plant to grow and tolerate water contaminated with kerosene and carry out biological processes such as photosynthesis (Fernandez et al. 2011). Dry weight increased with plant growth during 72 days but was not significantly different between the treatments with and without the addition of bacteria ($p>0.05$) show in (Figure 3).

Count Root microbial

The microbial population in Typha domingensis Root was evaluated through 72 d under the following conditions: plant with bacteria, plant without bacteria and control. The maximum CFU/mL value was achieved in root plant with bacteria after 72 day. The microbial population in root Typha domingensis of with and without bacteria in contaminant water and the control aquarium without contaminants 285×10-6,155×10-6 and 78 ×10-6 respectively. The presence of hydrocarbon contaminants and root executed has led to a change in number and species of microorganisms in the rhizosphere (Escalante-Espinosa et al., 2005) show in (Figure 4).

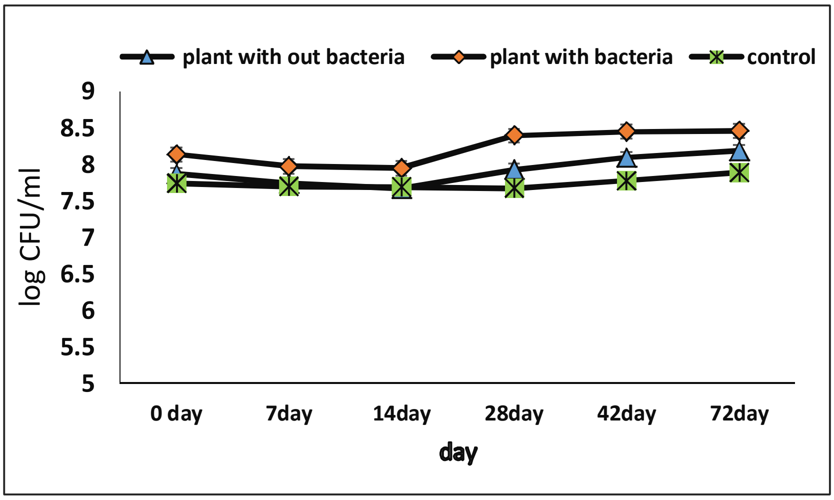

Figure 4: Total count of the rhizobacteria population during the 72 days in the phytotoxicity test of *T. domingensis* with 5% kerosene.

Total petroleum hydrocarbon in water

The residual quantity of kerosene in water was analysed to determine the effects of plant with and without bacteria, bacteria and environment factor on kerosene removal. Through 72, kerosene concentration reduces from water in all basins. The maximum removal percentage in plant with bacteria .total petroleum hydrocarbon removal percentage in plant with and without bacteria, bacteria and control were 81.9%, 76.5%, 74.1% and 57.4% respectively represent in (Figure 5).

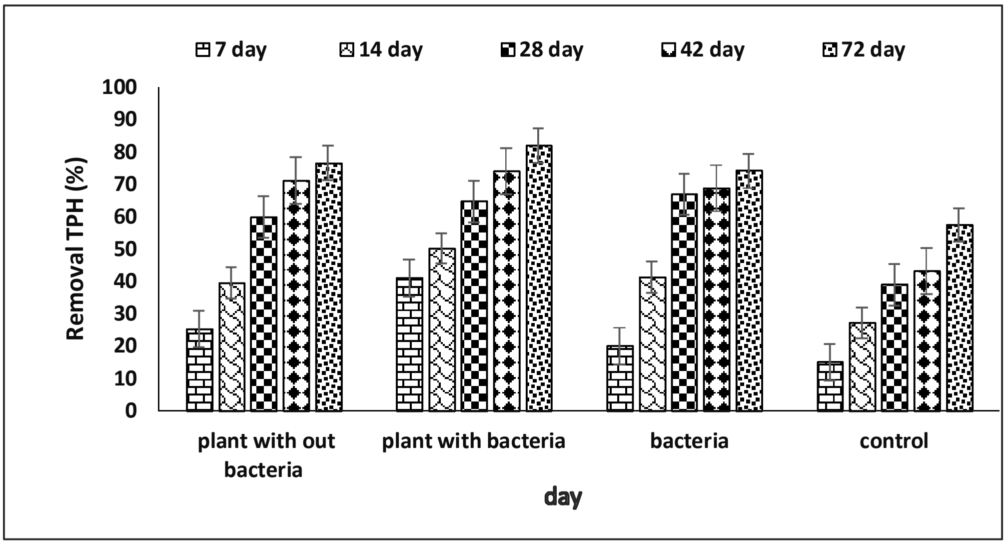

Figure 5: TPH degradation in water by *T. domingensis* exposed to 5% kerosene contamination

Phytoremediation have mechanism such as phytoevaporation ,Phytodegradation, Rhizofiltration, rhizodegradation responspable on degradation petroleum hydrocarbon , in addition that plant release organic compound that increase number of microorganism in rhizosphere which degrade petroleum hydrocarbon (Cai et al. 2010) AS due reduce of TPH in water to photooxidiation ,adsorption ,absorption ,biodegradation by indigenous microorganism in soil and water and evaporation (Imfeld et al., 2009). Construction wetland contain plant achieved highest reduce of TPH from water because growth root plant in substrate enhance reduce TPH from rhizosphere (Agamuthu et al., 2010). Addition bacteria to plant play important role in treatment petroleum hydrocarbon this result agree with (Al-Baldawi et al., 2017).

Total petroleum hydrocarbon analysis in plants

During the phytoremediation period of 72 day, plants were sample (0, 7, 14, 28, 42, 72) day. The result show increasing total petroleum hydrocarbon in Typha domingensis tissue through 72 day. Correlation coefficients for the accumulation in plant with time (r=0.932) ($p<0.01$).Total petroleum hydrocarbon accumulation achieve significantly different Between plant with and without bacteria this agree with (Al-Baldawi, 2017).ability of plant to uptake petroleum hydrocarbon depended on root this due through Large surface area that help to adsorption petroleum hydrocarbon in root tissue and then absorption.(Al-Mansoory, 2015) show in (Figure 6).

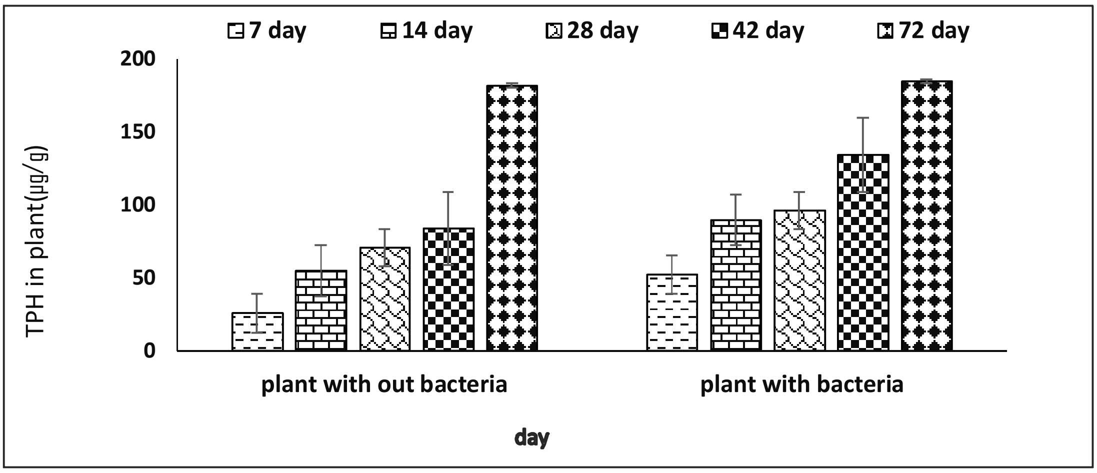

Figure 6:TPH degradation in plant by *T. domingensis* exposed to 5% kerosene contamination

Conclusions:

In this study, treatment water contaminant with kerosene in construction wetlands contain *Typha domingensis* with bacteria Performed more effectively than without bacteria .In addition, has enhanced plant growth of *Typha domingensis* and bacterial populations compared to without bacteria. Addition bacteria to plant (*Typha domingensis*) increase accumulation of TPH in plant tissue. Increase total petroleum hydrocarbon in plant tissue lead to withered plant after 42 day . Construction wetlands play essential role in decrease Biological Demanded Oxygen (BOD_5).

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