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Synergistic Efficiency Between Types of Fungi and Algae for Wastewater Treatment

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ABSTRACT

The study aims to demonstrate the efficiency of the synergy between types of fungi and algae for wastewater treatment. Samples are collected from the waters of Wadi al-Kharazi inside the University of Mosul. Four genera of organisms, two sexes of fungi, and two sexes of algae are used for the purpose of reacting.

Examinations are conducted for water treated with fungi and algae, as 8 treatments are used compared to the control treatment that contains water alone. The pH function, bicarbonate ions, and sulfates with the two elements iron and copper are measured.

The results of the bicarbonate examination show that the best biological treatment is in the mixed culturing of the alga *Spirogyra maxima* and the fungus *Trichoderma asperallum*. The average concentration during the incubation periods is 162.8 mg.l^{-1} compared to the average control treatment ranging 204.9 mg.l^{-1}. The results of the sulfate examination show a decrease in concentration for all treatments compared to the control treatment. The best biological treatment in the mixed culturing is between the alga *Spirogyra maxima* and the fungus *Mucor racemosus,* as the removal rate reached 48% compared to the average of the control treatment. Examinations have demonstrated the synergy between fungi and algae in increasing the efficiency of pollutant removal rather than using both separately.

Keywords- Phosphate, removal, Molecular, Diagnostics, Fungi.

I. INTRODUCTION

Wastewater pollution is a growing global problem resulting from rapid industrialization, and has been largely unrecognized, with more than 50% of the world's population living in coastal cities (Abaya *et al*, 2018). Untreated wastewater is introduced to water assets from accidental spills of failed treatment plants. These include sewer overflows, broken sewer pipes, clogged lift stations, and effluent discharged from on-site sewage disposal systems. From an environmental point of view, it is regarded a complex problem as it contains a mixture of high levels of hazardous pollutants. Wastewater contains pathogens (bacteria and viruses), organic and inorganic compounds, endocrine disruptors and hydrocarbons (Ahmed et al, 2018).

The applications of using fungi in biological treatment are known as mycoremediation. Fungi are microorganisms with unique properties having the ability to produce various degrading enzymes which has led to their use in biological treatments. Its enzymes have been used to analyze pollutants more in bioremediation applications compared to bacteria due to their ability to overcome some environmental aspects such as the toxicity of persistent organic compounds as well as heavy metals that may limit or prevent biodegradation by bacteria (Sankaran et al., 2010). Moreover, fungi are apical organisms that obtain carbon and energy sources through the decomposition of organic matter by hydrolytic enzymes (Verma et al., 2017).

The use of algae in the biological treatment of water is one of the best methods used in the treatment as

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it has a high ability to remove carbon, nitrogen and phosphorous from polluted water, as well as the fact that it does not require energy and the use of chemicals as it works to reduce the formation of silt. On the contrary, the use of algae in biological treatment is one of the techniques that produce fuel and some economically effective chemicals (Roa, 2012).

II. MATERIALS AND WORK METHODS

Wastewater samples are collected in May from the Wadi Al-Kharazi stream inside the University of Mosul, near the gate of the Deanship of Veterinary Medicine. The simple photobioreactors consist of (6) liter and 8 glass containers for growing algae and fungi in sewage water and a control treatment containing waste water only with the addition of an aeration system. As (300) ml of fresh algae pollen is added to each of the used algae genera, while for fungi, 100 ml of fungal pollen are also added from each genera. The pollen is added to the waste water at a rate of 3500 ml per glass container. This system is equipped with a rubber tube and the use of an air pump that is used in fish ponds to pump air. These bioreactors are placed in a controlled cultivating room at a temperature of 25°C ± 2 and an illumination of 2500 lux, with the light succession of 16 hours of light and 8 hours of darkness (Falch et al., 1995).

An amount of 300 ml is taken weekly for the purpose of conducting water examinations for a period of 30 days. Two sexes of fungi and two sexes of algae are used and divided as in Table (1) onto containers jointly and individually to find out the most efficient treatment in removing pollutants as follows:

Treatments	No.
Trichoderma asperallum coefficient only	.1
coefficient only *Mucor racemosus*	.2
Spirogyra maxima coefficient only	.3
Mixed cultivation coefficient between *S. maxima* and *T. asperallum*	.4
Mixed cultivation of the algae *S. maxima* and the fungus *M. racemosus*	.5
Gloeocapsa rupicoig coefficient only	.6
Mixed cultivation coefficient between *G. rupicoig* and *T. asperallum*	.7
Mixed cultivation coefficient between *G. rupicoig* and *M. racemosus*	.8
Control	.9

The pH function is measured in the laboratory by a pH-Meter after organizing the device with buffer solutions for the pH function, according to the method by APHA (2017).

As for the concentration of bicarbonate ions the measuring is according to the method mentioned by APHA(1985.1998) from the following equation:

$$HCO_3(mg.L^{-1}) = \frac{V \times N \times 61 \times 1000}{\text{ml of sample}}$$

As for the sulfate ions, the method described in APHA (1985) is the one followed by using a spectrophotometer with a wavelength of 420 nm and the result is expressed by $mg.l^1$.

The elements are measured with the AnaIytik Jena GmbH-novAA350-Flame Atomic Absorption Spectrometer and concentration is expressed in (mg.l-1) as indicated by APHA (1985, 2017).

III. RESULTS AND DISCUSSION

The results of the acidity function test show an increase in the concentration compared to the average of the control treatment. There is a high rate of mixed culture concentration between *G. rupicoig* and *M. racemosus*, reaching 7.9 during the incubation period, while there is also a decrease in the rate of the acidity function with the treatment of *T. asperallum* and the treatment of *T. benhamiae* with an average concentration during the incubation period of 7.6 compared to the control treatment of 7.7.

The increase in pH values may be attributed to the effect of bicarbonate ions resulting from the dissolution of carbonate compounds that behave like a buffer solution (Al-Tai, 2021) as shown in the following equation (Manhan, 2004):

$$HCO_3^- + H2O \overset{hr}{\rightarrow} \{CH_2O\} + O_2 + OH^-$$

As for the decrease, it may be attributed to the severity of the metabolic changes of the fungi, as the fungi have different regulating mechanisms for the pH due to the environment in which they are located, depending on the initial pH. The detergents present in the wastewater can also act as a strong alkaline agent that can affect the genes of the fungi and stimulate their secretion of organic acids (Jakovljević, Vrvić., 2016).

As for bicarbonates, the results show that the best biological treatment is in the mixed cultivation between *S. maxima* and *T. asperallum*. The average concentration during the incubation periods is 162.8 $mg.l^{-1}$ compared to the average of the control coefficient of 204.9 $mg.l^{-1}$, as well as compared to the concentration of the alga *S. maxima* alone and that of the fungus *T. asperallum* alone reaching 185.4 and 195.8 $mg.l^{-1}$, respectively. This shows an increase in the removal efficiency when there is a synergistic effect between the alga *S. maxima* and the fungus *T. asperallum*, as the removal rate has reached 25%, while the lowest efficiency is in the alga *G. rupicoig* coefficient, as shown in Figure (1). The decrease may be attributed to the self-purification processes carried out by aquatic organisms, such as sedimentation processes and the possibility of CO2 consumption associated with bicarbonate ions and

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converting it to the form of precipitated carbonates, as in the two equations (Al-Safawi and Al-Sard, 2013):

$$2HCO_3^{-}+CO_2+CO_3^{-}+H_2O$$
$$CO_3^{-}+H_2O \rightarrow CO_2+2OH^{-}$$

As for the rise, it may be due to the concentration of organic materials that are attacked by aerobic microorganisms, including algae, leading to the production of both CO2 and carboxylic acids, which react with calcium carbonate in sediments and suspended matter and turn it into calcium bicarbonate dissolved in water, as in the following equations (Al-Safawi, 2007; Manhan, 2004):

$$\{CH_2O\}+O_2 \xrightarrow{Microorganisms} CO_2 + H_2O$$
$$H_2CO_3+CaCO3\downarrow \rightarrow Ca(HCO_3)_2$$

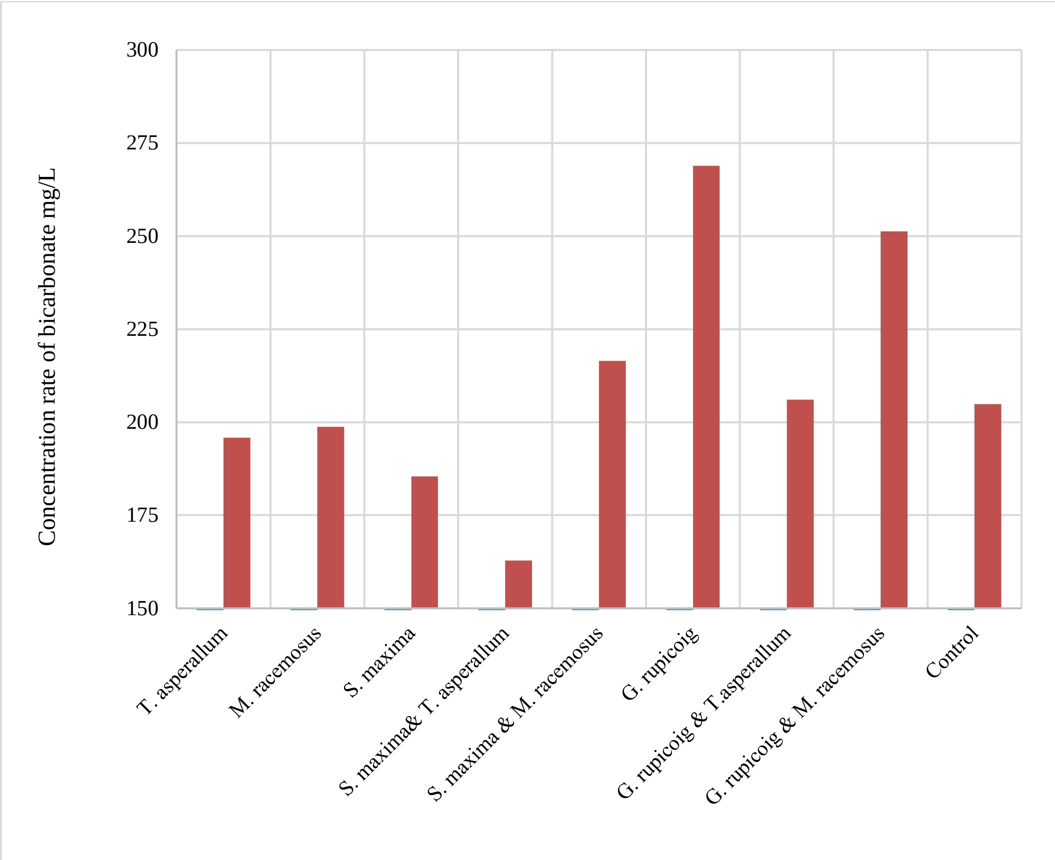

Figure 1: Average concentration of bicarbonate during incubation periods mg.l^{-1}

As for the sulfate assay, the results show a decrease in the concentration of sulfate ions for all treatments compared to the control coefficient. The best biological treatment is in the mixed cultivation between *S. maxima* and *M. racemosus*, as the average concentration in the treatments during a period is 153.6 mg.l^{-1} and a removal rate of 48% compared to the average of the control coefficient, which is 296.4 mg.l^{-1}. It is the least efficient in biological treatment as shown in Figure (2) in the *T. asperallum* fungus treatment., where the concentration rate in the treatment is 191.3 mg.l^{-1} with a removal rate of 35% compared to the control coefficient. The rise in values may be attributed to the water containing organic and protein waste and as a result of the biological reactions carried out by living organisms and the oxidation and reduction processes that occur, as shown in the following equations: (Al-Safawi, 2007; Ibrahim, 2022)

$$CaSO_4 + 3(CH_2O) \rightarrow CaCO_3 + 2S^{=} + 3H_2CO_3$$
$$C3H7O2NS+8H_2O \rightarrow 4H_2S + CH_3COOH + 4NH_3$$
$$S^{=}+2H^{-} \rightarrow H_2S$$

Oxidation processes occur upon exposure to oxygen, as in the following equation:

$$H_2S+2O_2 \rightarrow H_2SO_4$$

Either the decrease in the values may be attributed to the sedimentation processes as well as to the PHotochemical reaction by the influence of solar radiation and the formation of precipitated products or through biological absorption by algae, as well as absorption by other microorganisms for its importance in the construction of some amino acids and proteins (Al-Sinjari, 2013).

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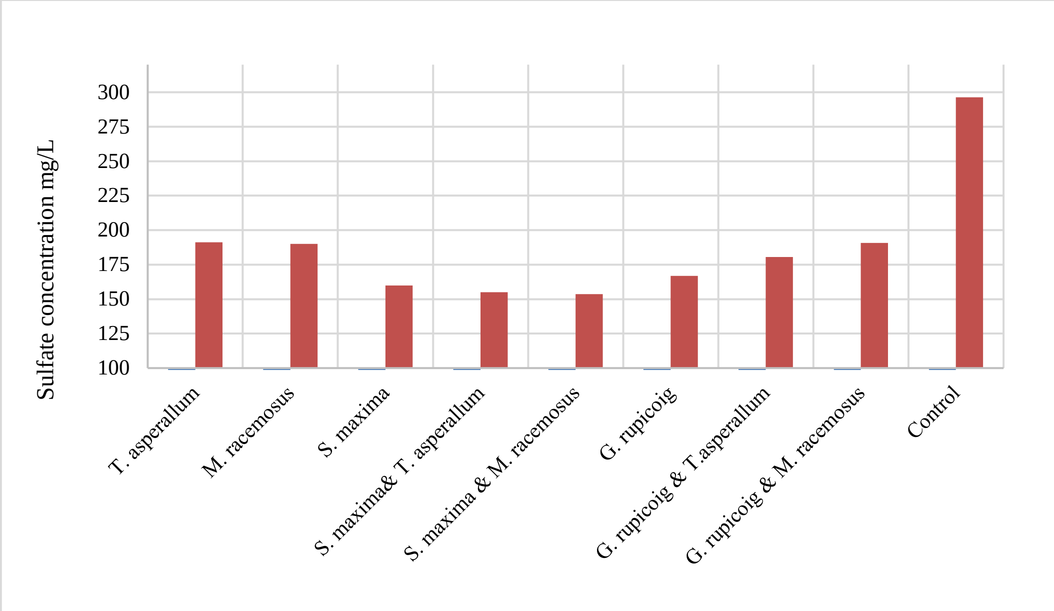

Figure 2: Average sulfate concentration during incubation periods mg.l^{-1}

As for the measurement of copper and iron, the results of the examination show the best biological treatment by copper in mixed cultivation between *S. maxima* and *M. racemosus*.The concentration at the end of the incubation period is 0.0597 mg.l^{-1} with a removal rate of 49% compared to the control coefficient, in which the average concentration in the end of the incubation period is 0.1175 mg.l^{-1}. The lowest efficiency in the biological treatment and compared to the control coefficient in the alga *S. maxima*, where the concentration at the end of treatment is 0.354 mg.l^{-1} as shown in Figure (3).

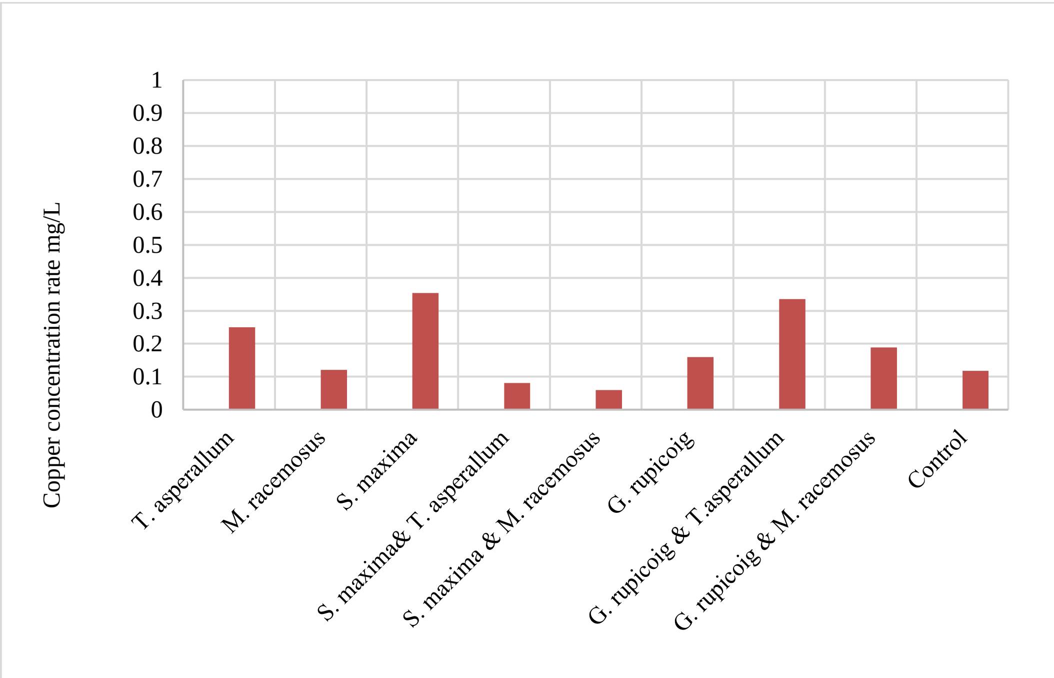

Figure 3: Average concentration of copper during incubation periods mg.l^{-1}

As for iron, the results show a significant decrease in the concentration, as it is the best biological treatment in the algae *G. rupicoig*. The concentration rate at the end of the treatment is 0.3664 mg.l^{-1} with a removal rate of 68% compared to the control coefficient, which has a concentration of 1.1541 mg.l^{-1}, while it is less efficient compared to the control coefficient in *S. maxima* algae, where the concentration at the end of treatment is 1.2051 mg.l^{-1}, as shown in Figure (4).

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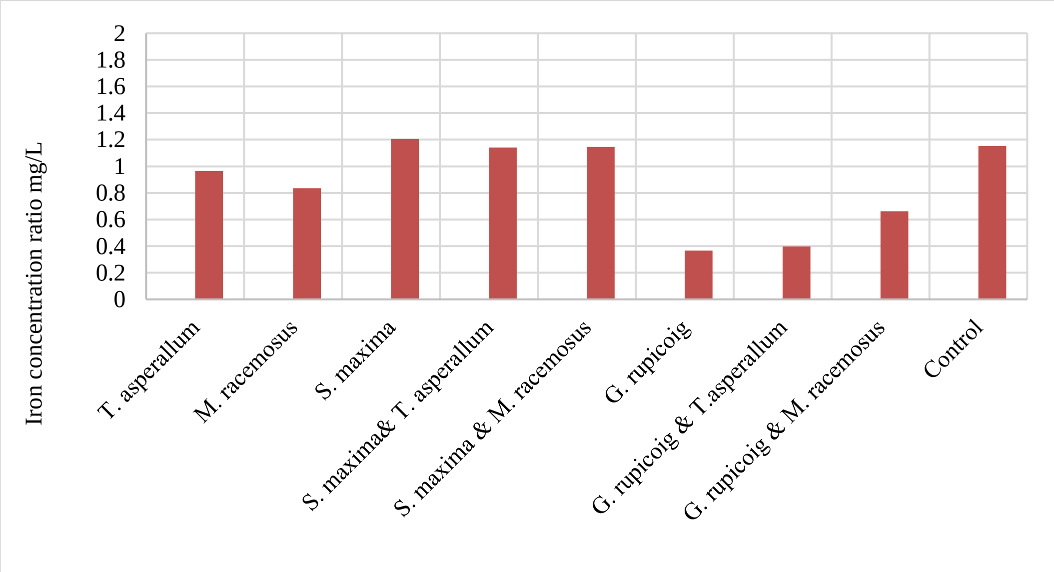

Figure 4: Iron concentration during incubation periods mg.l^{-1}

The possibility of an increase in some elements may be attributed to the decomposition processes of organic compounds and suspended compounds, which causes its high concentration in water, as well as the possibility of not being absorbed by living organisms or linking them to the products of these organisms to turn them into non-absorbable forms.

In general, heavy elements are affected by variable factors (temperature, pH), as well as the ability of aquatic organisms to absorb these ions. The acidic pH increases the concentrations of absorbable ions due to its increased solubility, while the relatively basal pH absorbs and precipitates heavy elements, as well as the joint role of microorganisms that contribute to the absorption of those elements (Salman et al., 2010).

We conclude from this study that the process of synergy between algae and fungi is more efficient in the process of removing pollutants, making it the best method for treatment instead of using algae and fungi separately.

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