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Efficiency testing of Algal Chlorella Sorokin Ana and Coelastrella sp. to reduce carbon dioxide

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***Abstract*---**Tested Bio-mitigation to reduce greenhouse gas technology dioxide levels through the use of isolates belonging to the Division of green algae. Chlorella sorokiniana. GenBank databasr (accession No. MH923013.1) and Coelastrella sp. Gen Bank database (accession No. MH 923012), Within five different CO2 levels of 5, 10, 15, 20 and 25 L / min during the 24-day laboratory study period grown with NPK culture medium, The study showed that Chlorella sorokiniana is more efficient than Coelastrella sp. Through the treatment time for gas, which reached 92.94% of Chlorella sorokiniana after 3 days from the start of the study, the highest level of gas was 25 L / min, which was equivalent to 6000 mg / l. In addition to producing biomass weights compared to the biomass weights of Coelastrella sp, the biomass of Chlorella sorokiniana also produced more biochemical contents than those of Coelastrella sp, represented by the ratios of Lipid, anthocyanins, and carotenoids. The results of the study also showed an exponential increase in the uniform optical density of Chlorella sorokiniana within the five gas levels, which amounted to 0.294, 0.311, 0.345, 0.431 and 0.511 nm, respectively, compared to the control of 0.098 nm for day 24 of culture. As for the optical density of Coelastrella sp, it was irregular in growth within the farms supplied with gas rates. The optical density was 0.501, 0.429, 0.619, 0.651 and

0.589 nm with gas quantities of 20, 15, 25, 5 and 10 L / min, respectively, compared to the control that It reached 0.102 nm.

***Keywords*---**bio-mitigation, reduce carbon dioxide, optical density, algal, greenhouse, biomass.

Introduction

Microalgae cultivation for CO2 absorption is a costly technique. However, if the biomass generated is utilized for both carbon reduction and other reasons, it may be made economically feasible. Algae biomass has the potential to play a significant role in ensuring food security for both animals and humans. Microalgae have a high nutritional value due to the variety of vital components they contain, including provitamins, minerals, and polyunsaturated fatty acids (Pandey and Tiwari, 2010). Carbon is the most significant ingredient for microalgal development, followed by nitrogen and phosphorus (microalgal biomass comprises roughly 50% w/w carbon generated entirely from CO2). As a result, the generation of 1 g of microalgal biomass correlates to roughly 1.83 g of CO2 fixation, suggesting that these microorganisms may be efficiently used in CO2 capture (Cheah et al., 2015). Microalgae can repair CO2 from the environment as well as flue gas emissions. The use of atmospheric CO2 offers for more freedom in locating the microalgal facility since it does not need to be adjacent to a CO2 emission source and does not need CO2 carrying equipment (Moreira and Pires 2016). They include important amino acids, notably sulphur-containing amino acids, that are often lacking in most human diets (Kolb et al., 2004). They are also high in polyunsaturated fatty acids such as omega 3 fatty acids, hexadecatetraenoic acid methyl ester, octadecatetraenoic acid methyl ester, eicosapentaenoic acid methyl ester, docosahexaenoic acid methyl ester, arachidonic acid, and -linolenic acid (Spolaore et al., 2006).

Microalgae are thought to be an excellent source of protein for people, animals, and fish raised in aquaculture hatcheries. However, microalgae cultivated in wastewater treatment plant effluent should not be consumed by people, animals, or fish since they may contain a range of pollutants ranging from heavy metals and pesticide residues to harmful bacteria and viruses. Microalgae also contain bioactive chemicals that have medical use (Gustafson, 2004). Algae is a rich source of nutraceuticals because of many of them, including lipid anti-oxidants, -carotene, sterols, and toxins (Rasmussen et al., 2007). The therapeutic impact of microalgae-based remedies on disorders related with oxidative stress has received a lot of interest (Chen et al., 2009). Because of their qualities, microalgae may be utilized to treat a variety of medical ailments. They are anti-bacterials, bronchodilators, polysynaptic blockers, and analgesics, for example, and they prevent odema, convulsions, and inflammation. The compounds discovered in algae biomass hosts that may be used to produce money in the industrial sector. Sugars, polysaccharides, dyes, bio flocculants, pigments, and oils are also produced by microalgae (Pereira et al., 2009).

Materials and Methods
Diagnosis, isolation and development of algae

Microalgae used in the current study was (*Chlorella sorokiniana*. GenBank databasr (accession No. MH923013.1), and *Coelastrella* sp. Gen Bank database (accession No. MH 923012) that genetically diagnosed by the researcher (Abed et al., 2018). They were isolated from the aquatic environment and the reliance on diagnostic sources (2010 et al., Edward). Algae isolates were grown on local NPK under controlled environmental conditions such as light intensity, temperature and pH., (Iraq aquatic environment) (Abed et al., 2018). Fig (1,2).

Division: Chlorophyta
Class: Chlorophyceae
Order: Chlorococcales
Family: Chlorococcaceae
Genus: *Chlorella*
Species: *Chlorella sorokiniana*

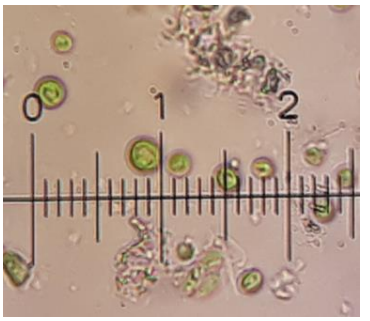

Fig 1. *Chlorella sorokiniana*

Classification of *Coelastrella* sp. (Hegewald *et al.*, 2010).

Domain: Eukaryotes
Division: Chlorophyta
Class: Chlorophyceae
Order: Sphaeropleales
Family: Scenedesmaceae
Genus: Coelastrella

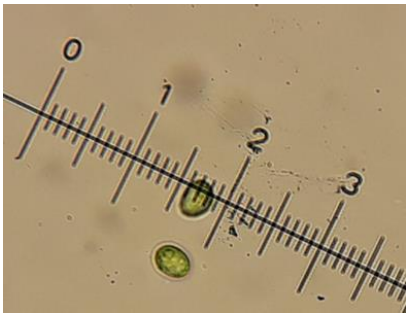

Fig 2. *Coelastrella* sp

Laboratory experiments

NPK was used as media to grow microalgal isolates with different flow rate of CO_2 (5, 10, 15, 20 and 25) L / min and compared to control culture. Each treatment contains 10 liters of microalgae culture. In addition, each farm was equipped with an air pump to ensure complete dissolution of the gas, while the pH and the appropriate light intensity were recorded. The figures show the use of *Chlorella sorokiniana* and *Coelastrella* sp. respectively.

Optical density

The optical density of the microalgal culture was monitored using a spectrophotometer at a wavelength of 680 nm over a 24-day period to follow the growth phases and reach the stability phase and the harvesting process. all measurements were done in duplicate. The growth rate (K) was calculated according to following equation (Huang *et al.*, 2002).

$$K = \frac{(\text{Log OD}_t - \log \text{OD}_0)}{t} \times 3.322$$

t: time (days)
OD_t: Growth after (t) days.
OD_0: algal growth at zero time.

CO_2 gas meter

It is a digital field device produced by the American company (TSI) used to measure the concentration of carbon dioxide and monoxide gases.

Extraction of chemical contents
Extraction and estimation of lipids

The lipids was estimated according to the method (A.O.A.C, 1995), where the dried sample was taken and placed in the filter paper and roll it, put it in the lipid extractor (Soxhlet) and then the weight of the flask of the device was measured, 25 ml of hexane was added to it. The extraction process continued for about 5 hours, the solvent was collected from the apparatus, the flask was removed and placed in an electric oven for half an hour at a temperature of 60 ℃ to ensure that the residue of the hexane was rid of from the flask and the lipid remained, and then get out the flask from the oven, leave it until it cools. Then the weight of flask was measured. The lipid ratio was calculated according to the following formula:

$$\text{F\%} = (\frac{W_1 - W_2}{W_S}) \times 100$$

Were, F%: Fat percentage
W1: Weight of flask before extraction
W2: Weight of flask after extraction
Ws: Sample weight

Determination of total anthocyanin content

The pH-differential method was used to calculate the total anthocyanin content (TAC). Anthocyanin pigments exhibit reversible structural alterations in response to pH changes, resulting in noticeably altered absorbance spectra. At pH 1.0, the colorful oxonium form predominates, whereas at pH 4.5, the colorless hemiketal form predominates. Based on this process, the pH-differential approach allows for accurate and speedy determination of total anthocyanins, even in the presence of polymerized damaged pigments and other interfering chemicals .Transfer 1 mL of the extracted solution into a 10 mL volumetric flask for two dilutions of the sample, one with potassium chloride buffer, pH 1.0, and the other with sodium acetate buffer, pH 4.5, diluting each. Allow these dilutions to equilibrate for 15 minutes. Measure the absorbance of each dilution against a blank cell filled with distilled water at 510 and 700 nm (to adjust for haze). Because longer standing durations tend to increase observed values, all measurements should be taken within 15 minutes and 1 hour following sample preparation. Water blanks are used to take absorbance measurements. The measured samples should be clean and free of haze or sediments; nonetheless, certain colloidal elements may be suspended in the sample, generating light scattering and a foggy appearance (haze). This light scattering must be compensated for by reading at a wavelength where there is no absorbance of the sample, i.e., 700 nm. Determine the absorbance (A) of the diluted sample as follows:

$$\mathbf{A = (A510– A700)\ pH\ 1.0 – (A510– A700)\ pH\ 4.5}$$

Using the following formula, calculate the monomeric anthocyanin pigment concentration in the original sample:

$$\mathbf{anthocyanin\ pigment\ (mg/L) = (A \times MW \times DF \times 1000) / (\varepsilon x1)}$$

It was then translated to mg of total anthocyanin content per 100 g sample. Calculate pigment content as cyanidin-3-glucoside, where MW = 449.2, DF = 26,900, and is the molar absorptivity. (Sutharut and Sudarat, 2012).

Total Carotenoids

40 mg of fresh leaves were placed in 10 ml of 80 percent (v/v) acetone and shaken for 30 minutes before being exposed to ultrasonic waves for 10 minutes and maintained in the refrigerator for 1-2 days. After three days, the supernatant was collected and the color intensity was assessed using a UV-VIS spectrophotometer at 480, 510, and 652 nm. The quantity of carotene in milligrams per liter was determined using the following formulas:

Carotenoids =7.6 x (O.D. at 480 nm) –1.49 x (O.D. at 510 nm) (Haresh and Shashank, 2014)

Results and Discussions

Use of *Chlorella sorokiniana*
Optical Density

Chlorella sorokiniana was cultured within five cultures equipped with different CO_2 gas rates represented by 5, 10, 15, 20, and 25 L / min with an air pump for each culture compared to a control culture free of CO_2. The optical density was measured at a wavelength of 680 nm for all cultures with control culture daily for 24 days. The culture that pumped with 25 liters/min of gas had the best growth rate than the other cultures, through the exponential increase of the microalgal living mass, followed by the other of the flow rates, which were represented by 20, 15, 10, and 5 L / min. While lower optical density was recorded in the control culture as can be seen in Figure 3.

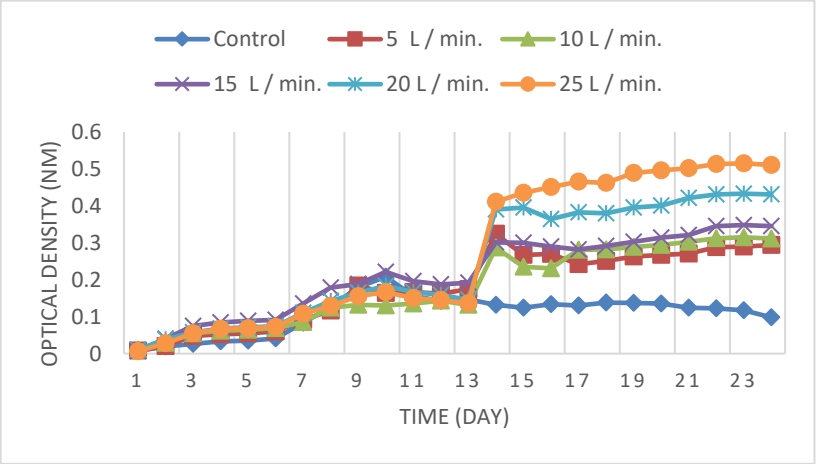

Figure 3. The optical density of *Chlorella sorokiniana* grown in different rates of CO_2

After the Cultivation process of algae within the cultures equipped with CO_2 gas and each culture has a special rate of gas, the process of adaptation of the algal cultures to the culture media equipped with gas was observed. This was confirmed by a study (Bhakta et al., 2015) of growing *Scenedesmus* and *Chlorella* algae with a culture medium containing a high Concentration of CO_2. The study (Al-Husseini, 2014) also indicates the multiplication of algal cultures and their adaptation to the environment equipped with gas, by providing all the ideal environmental conditions of temperature, intensity of illumination, pH values and a suitable surface area with stirring and constant movement of the cultures with an air pump to ensure the homogeneity of the agricultural medium. It is knowing that green algae have the ability to capture large quantities of CO_2 gas through the surface area characterized by the *Chlorella* sp. algae cell.

Carbon dioxide reduction in *Chlorella sorokiniana* plantations

Carbon dioxide is an important food source for algae. As the concentrations of gas levels prepared for algae cultures were measured at a flow rate of 5, 10, 15, 20,

and 25 liters/minute, which are equivalent to the value of (mg /liter) to 2000, 3000, 4000, 5000 and 6000 mg/liter, respectively. The gas concentrations in algae cultures were measured before the gas pumping process, which amounted to 710, 719, 706, 698, and 691 mg/liter, respectively, while the control cultures reached 704 mg/liter, which is the product of the air pump equipped for the cultures for the process of stirring and mixing the agricultural medium. After 3 days of pumping the gas, the concentrations of different levels of gas were measured, which reached 875, 438, 1320, 1342, and 452 mg/liter, respectively, with a percentage removal rate of 60.67, 85.42, 73.00, 74.21, and 92.24%, respectively, compared to the control culture. 18.96% as a removal rate (Table 1).

Table 1
Shows the value of CO_2 in mg / liter unit and treated within 3 days in a laboratory with *Chlorella sorokiniana*

CO2 gas levels l/min	Before gas processing mg/L	After gas processing mg/L	Treatment after 3 days mg/L	percentage removal (%)
Control	627	543	440	18.96
5	710	2000	875	60.67
10	719	3000	438	85.49
15	706	4000	1320	73.00
20	698	5000	1342	74.21
25	691	6000	452	92.94

Microalgae may develop in autotrophic environments by using light and carbon dioxide. In addition to carbon dioxide and an organic substrate as carbon sources, organic molecules are employed as an energy source (Chojnacka and Facundo-Joaquin, 2004). As for the specialized enzyme systems within the green algae cell wall, they consume amounts of CO_2 concentrations that exceed what the cell needs from a carbon nutrient source. Part of CO_2 consumed by algae is used in photosynthesis to build cellular compounds and the other part is stored in several forms in addition to the carbon stored inside the cells (Durán et al., 2018).

Biochemical investigations of the Biomass of *Chlorella sorokiniana*

The algae biomass contains valuable substances through various types of products such as carbohydrates, fats, proteins, starch, cellulose, polyunsaturated fatty acids, dyes, and food preservatives. In addition to the presence of antioxidants, pharmaceutical materials and fertilizers (Trivedi et al., 2015). Among the microalgae with high productivity of these products is *Chlorella* sp. In various countries such as China, Japan, Europe and the United States have obtained high quantities of the living mass of algae. Up to 2000 tons / year, through which many chemicals used in the medical, food and industrial fields were extracted (Thangave and Arivalagan, 2019). Biochemical compounds were detected after the completion of the harvesting process for algae cultures after 24 days. The proteins of *Chlorella sorokiniana* were measured at different gas flow rates. The proportion of proteins reached 36.22, 37.26, 42.12, 44.25 and 47.08%,

respectively, compared to the control which amounted to 31.32%, as shown in Table (2).

Table 2
Chemical compounds extracted from the living mass of *Chlorella sorokiniana* and grown at different rates of pure CO_2

Name	Lipid %	T.antho (ppm) Total anthocyanin content	T.carotene (ppm) Total Carotenoids
Control	20.35	1,00	10.25
5	29.14	1.12	11.08
10	31.26	1.23	11.56
15	31.76	1.48	11.98
20	32.11	1.79	13.08
25	34.05	2.89	13.58

The percentage of lipids in the biomass of *Chlorella sorokiniana* for different gas levels within the algae cultures reached 29.14, 31.26, 31.76, 32.11 and 34.05%, respectively, compared to the control that amounted to 20.35%. (Table1). The process of producing biochemical products from algae is based on microalgae strain to produce dyes, antioxidants, b-carotene, multiple sugars, triglycerides, fatty acids, vitamins, phenols, etc., as well as the presence of nutrients with the carbon source represented by CO_2 (Barrow and Shahidi, 2007). Therefore, the study (Ponnuswamy, 2014) agrees with the current study by increasing the percentage of fats by a maximum of 40% from the increase of the living mass and by preparing the highest rate of CO_2 gas as well as the salts fed by the agricultural medium used for development and multiplication. The results of the current study indicate an increase in the percentage of fats by exposing the algal cultures to the appropriate light intensity, in addition to equipping the algal cultures with a carbon source, which was clear on the amount of fat productivity. That is, the photo-feeding system has a positive effect on the production of fats, which matches the study of (Saifuddin et al., 2015). Microalgae has recently gained significant interest worldwide due to its wide application potential in the renewable energy and biopharmaceutical industries. Microalgae have the potential for regeneration and sustainability or are included in the economic sources of biofuels, biologically active medicinal products and food ingredients. Many types of microalgae have the potential to produce value-added substances with remarkable medicinal and biological properties.

As the results of the current study showed the concentrations of anthocyanin within the biomass of *Chlorella sorokiniana* grown in cultures equipped with gas levels within the algae cultures, which reached concentrations of anthocyanin production at 1.12, 1.23, 1.48, 1.79 and 2.89 mg / liter, respectively, compared to the control, which amounted to 1.00. Mg/L (Table 1). Anthocyanin pigment is an important pigment with an oxidizing role for bacterial and fungal contaminants, and it is one of the green algae products that depend on the polarization of blue light from the sun's rays. It has a protective role for plants and algae, especially

for protecting plastids while absorbing sunlight. The blue light (ultraviolet rays accompanying sunlight) has an effect on the photosynthesis of the plastids. However, the presence of anthocyanin that absorbs 43% of the light energy protects the plastics from the risk of ultraviolet radiation (Christie et al., 1994).

Microalgae have the ability to absorb carbon dioxide in the atmosphere and convert it into the production of energy represented by carbohydrates, fats, carotenoids and other bioactive products. Although microalgae are renewable sources of bio-energy and biopharmaceuticals in general, there are still some limitations and challenges that must be overcome to upgrade the technology from the experimental stage to the industrial level. The most difficult and critical issue is enhancing the rate of microalgae growth and product synthesis. The results of the current study indicate the amount of Carotenoids concentration within the algae biomass of *Chlorella sorokiniana* for gas rates within the algae cultures to 11.08, 11.56, 11.98, 13.08 and 13.58 mg / L, respectively, compared to the control. That amounted to 10.25 mg / L (Table 1). Carotenoids are one of the most important algae pigments and are powerful antioxidants for their anti-inflammatory, sunscreen and immune system-enhancing properties as well as their applications in food, feed and nutrients (Cheng et al., 2016).

Use *Coelastrella* sp.
Optical density

Coelastrella sp was cultured in NPK culture medium in five cultures equipped with different gas rates with an air pump for each culture, as well as a CO_2-free control culture. The optical density was measured at a wavelength of 680 nm for all cultures with the control culture daily for a period of 24 days. The culture equipped with 20 L/min of gas had the best growth of algal light density through the exponential increase of algal live mass, which amounted to 0.651 nm after 24 days of study. Followed by the rest of the levels represented by 15, 25, 10 and 5 liters / minute, which amounted to (0.619, 0.589, 0.429 and 0.501) nanometers, respectively. The least developed was the gas-free control culture, which reached a density of 0.102 nm 24 days after the start of the experiment (Fig.4).

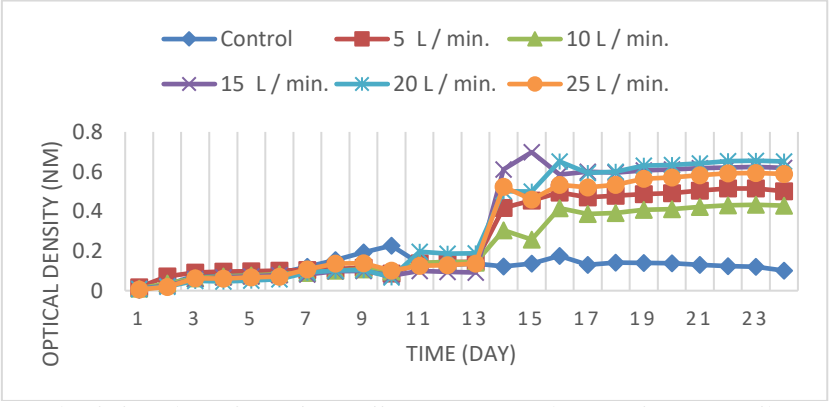

Figure 4. Optical density of *Coelastrella* sp. Grown in a culture medium equipped with different levels of CO_2 gas

The increase in algae biomass depends on the quality of the nutrient medium within a period of time that makes the growth process proceed regularly according to the stages of growth represented by the phase of adaptation or acclimatization to the nutrient medium. In order for the growth stages or phases to be according to the time periods of the culture, an appropriate quality of nutritious salts must be provided, and the most important nutrient salts for most algae are (K, N, P, C). The carbon element represented by CO_2 gas in the current study is the most important element as it is the main contributor to the process of increasing the Biomass through which promising products are obtained. Besides culture conditions, the selection of microalgae species is important because it directly influences photosynthetic efficiency and thus carbon-fixing performance and biomass production (Biesta et al., 2010)**.**

CO_2 reduction for algae culture *Coelastrella* sp. Laboratory

CO_2 gas is considered the high-efficiency food source and complementary with the rest of the salts that nourish the growth of algae, as the concentrations of gas rates that were prepared for algal cultures were measured 5, 10, 15, 20 and 25 liters / minute, which is equivalent to the value of mg / liter to 2000, 3000, 4000 and 5000 and 6000 mg/L, respectively. Gas concentrations were measured in algae cultures before gas processing, which amounted to 708, 707, 706, 703 and 701 mg/l, respectively, while the control culture amounted to 704 mg/l. It is a product of the air pump supplied to the cultures for the process of stirring and mixing the culture medium, and after 3 days of preparing the farms with gas, the concentrations of the different levels were measured, which reached 976, 1242, 1444, 1400 and 1076 mg/liter, respectively. With a percentage removal rate of 55.27, 60.24, 71.03, 72.00 and 82.06%, respectively, compared to the control culture of 26.88% as a removal percentage (Table 2).

Table 2
Shows the value of CO_2 gas in mg/L unit and its laboratory treatment within 3 days by *Coelastrella* sp

CO2 gas levels l/min	Before gas processing mg/L	After gas processing mg/L	Treatment after 3 days mg/L	percentage removal (%)
Control	704	610	446	26.88
5	708	2000	976	55.27
10	707	3000	2421	60.24
15	706	4000	4441	71.03
20	703	5000	1400	72.00
25	701	6000	1076	82.06

Algae develop and proliferate in response to the nutrients present in agricultural medium, the most significant of which are carbon, phosphate, and nitrogen. According to most research, the ratio that provides a balance of these nutrients is (40:7:1) (C: N:P) in a succession, until it reaches (106:16:1) correspondingly. According to research, the proportion of carbon in agricultural medium for the development and multiplication of algae is the greatest (Farooq et al., 2015).

Carbon is the most significant component for microalgae development, followed by nitrogen and phosphorus (microalgae biomass comprises around 50% w/w carbon, which is produced entirely from carbon dioxide). As a result, the creation of 1 g of microalgae biomass correlates to about 1.83 g of carbon dioxide fixation, suggesting that these microorganisms may be efficiently used to absorb carbon dioxide. (Chisti et al., 2016).

Biological chemical examinations

The lipid content of the biomass of *Coelastrella* sp. for different gas rates within algae farms to 26.58, 25.44, 28.98, 30.59 and 27.48%, respectively, compared to the control, which amounted to 20.89%. (Table 2). The production of microalgae biomass is assumed to be between 15 and 25 ha ton/year which corresponds to 4.5 – 7.5 ha ton/year of lipid production (Choong et al., 2020). In this way current studies seek to intensify the growth rate and lipid production of microalgae. Under special conditions, fats and carbohydrates can accumulate through supplying algal cultures to quantities of CO_2 gas supplementary to the work of nutrient media with higher concentrations than the carbon source (Li et al., 2015). As well as equipping algal cultures with nutrients such as N, P, C and K with the rest of the physical factors represented by temperature, light intensity and pH values (Aratboni et al., 2019). The results of the current study indicate an increase in the percentage of fat within the high gas rates, which amounted to 30.59% as the upper limit of the percentage of fat for the living mass of *Coelastrella* sp. Which matches most studies, such as the study of (Ingrid et al., 2020). By using the two isolates *Micractinium pusillum* and *Chlorella sorokiniana* isolated from wastewater and water treatment plant, the results showed a varied concentration of lipids, which reached 24.0% and 46.9%, respectively. This microalga makes it an interesting alternative source of biodiesel production.

Table 2
Chemical compounds extracted from the live mass of *Coelastrella* sp that grown at different rates of pure CO_2 gas

Name	Lipid %	T.antho (ppm) Total anthocyanin content	T.carotene (ppm) Total Carotenoids
Control	20.89	0.48	6.92
5	26.58	0.89	9.68
10	25.44	0.77	9.33
15	28.98	1.22	11.33
20	30.59	1.32	12.58
25	27.48	0.94	10.25

The concentration of anthocyanin within the biomass of *Coelastrella* sp. For different gas flowrate within algal cultures reached 0.89, 0.77, 1.22, 1.32 and 0.94 mg/L, respectively, compared to the control, which amounted to 0.48 mg/L (Table 2). The creation of biological activities of chemicals resulting from algal biomass, such as anthocyanin, depends on the nutrient salts, the most important

of which are N and P, as well as the carbon source in the form of CO_2 with complete and homogeneous dissolution with the nutrient salts (Kay, 2010). Anthocyanin's biological qualities are dependent on nutrition and temperature; therefore, its amounts or concentrations are minimal. Its biological and chemical relevance has given it an essential function as an oxidant and has extensive use in the prevention and even therapy of numerous human illnesses. It may also be used to suppress viruses that cause immunodeficiency, such as the cause of AIDS, as well as its powerful and efficient antiviral action against viruses A and B. (Ahmed et al., 2015).

Carotenoids pigment is one of the pigments that are contained in most types of algae, but green algae are the most types of algae that contain this pigment. The biomass of *Coelastrella* sp. The gas rates within algal cultures reached 9.68, 9.33, 11.33, 12.58 and 10.25 mg/L, respectively, compared to the control, which amounted to 6.92 mg/L (Table 2). The highest concentration of carotenoids was at the level of 20 liters / min of CO_2 gas, and the concentration of carotenoids was 12.58 mg / liter. The increase in the concentration of algal products, including carotenoid pigment, depends on the nature and type of the nutrient medium, as well as the amount of carbon source represented by CO_2 gas with the intensity of light. The study (Mulders et al., 2014) indicated the most important resources involved in the production of carotene pigment, including the intensity of lighting and the period of exposure to sunlight within a study in which *Chlorella sorokiniana* was used. The concentration of carotenoids was recorded to be 6.70 mg/gm in culture medium equipped with CO_2 gas, compared to 0.02 mg/gm in medium without CO_2 gas. Carotenoids also have the ability as antioxidant compounds and have the potential to interfere with the interaction between peroxy radicals. This assay involves initiating the oxidation process by generating water-soluble peroxylic radicals that are sensitive to all known chain-breaking antioxidants (Prior et al., 2005).

Conclusions and Recommendations

- The efficiency of *Chlorella sorokiniana* in reducing carbon dioxide in all its rates (5, 10, 15, 20 and 25 L / min.) is better than that of *Coelastrella* sp.
- Besides the culture conditions, the selection of the microalgae species is important because it directly affects the efficiency of photosynthesis, and thus the carbon fixation performance and biomass production.
- Further testing with actual flue gas from an electric power plant or industrial flue gas to see if it can be practically used to absorb flue gas emissions.
- Testing of many local isolates that are genetically diagnosed in their multiplication at rates of CO_2 gas and making use of biofuels, which is the global alternative fuel to fossil fuels.

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