WASTEWATER TREATMENT BY MICROALGAE

Siham Dehmani[a], Djamal Zerrouki [a]*

[a]*Univ. Ouargla, Fac. des sciences appliquées, Lab. dynamique interaction et réactivités des systèmes, BP 511, Route de Ghardaïa, Ouargla 30000, Algeria*

[*]Correspondingauthor :siham_dahmani@yahoo.com

a b s t r a c t

Domesticwastewatercontainshighnutrients concentrations such as nitrogen and phosphoruswhichcan affect public health and cause harmfulecological impacts. The potential of microalgae as a source of renewableenergybased on wastewater has receivedincreasinginterestworldwide in recentdecades. The microalgaecultivation in wastewater has twoadvantages: wastewatertreatment and algal biomass production.

Our workaimed to removenutrientsfromdomesticwastewater by chlorella.

Wastewaterswereobtainedfrom a wastewatertreatment plant located in Ouargla, Algeria. The experimentswereconducted in winterundernatural sunlight in an outdoor open raceway pond situated in the desert area. Analysis of differentparameterswasdoneevery 2 daysalong the period of the cultivation (19days). The averageremovalefficiencies of COD,BOD_5,NH_4^+-N and TP weremaintainedat 78%,87%,95% and 81% respectively .

Our results show the potential of integratingnutrientsremovalfromwastewater by microalgae as a secondarywastewatertreatmentprocesses.

Key words :Microalgae,Wastewater,Nutrientremoval,Secondarytreatment,Desert.

1. INTRODUCTION

Large-scalemicroalgal production islimited by variousfactorsthatwouldotherwiseensure an economicallyfeasibleprocess. Theseincludeselectionof a cultivation system (open or closed system),utilizing efficient microalgalstrains, the quantity and qualityof light, the availability of nutrients and carbondioxide (CO_2) tothe algae and a reliable source of water that has little or no environmentalimpact (Lam and Lee, 2012).

Nevertheless, production processes are stillunderdevelopmentand thereisconsiderable scope to reducecosts and improveefficiencywiththistechnology. Microalgalcultivationrequires largeamounts of water (Rawat et al., 2013). The impact of large-scalealgae production on water utilization has generatedgreatdebate.

Usingseawater, brackish water or WW wouldreduce the needfor freshwater (Komolafe et al., 2014).

Microalgae have been previouslyused for the treatment of WW(Komolafe et al., 2014; Ma et al., 2014). In turn, WW has beenshown to beeconomically viable and sustainable for the productionof microalgalbiomass (Yang et al., 2015). Recentfindings haveshownthatmicroalgae are able to grow and utilize the N and P

present in WW, thereby, removingthesenutrientsbeforeWWdischarge(Ma et al., 2014).Ammonia-N and P in secondary-treated WW are generally inthe range of 20–40 mg/L and 10 mg/L, respectively (Grady et al.,2011). Thesenutrient concentrations are deemedsufficient to supportthe growth of mostfreshwatermicroalgae (Olguín, 2012).Coupling WW

treatmentwithbiomassproduction is a very attractiveoption for energy, freshwater and fertilizerreduction. Thiswouldreduce the cost of WW treatmentincurred for nutrientremoval by conventionalmethods (Lam and Lee, 2012). Cultivationof microalgae in WW has the potential to reduce the N requirement
by up to 97% (Olguín, 2012). Wastewaterutilization as areplacement for freshwatercantotallynegate the need for additionalpotassium, magnesium and sulphur (Rawat et al., 2013).

This workassessed the suitability of domesticWWas a mediumfor cultivatingChlorellapyrenoidosa. The experimentswereconductedin the desert area in open pond systems. The studyalsoaimed to evaluate and compare the nutrientremovalefficienciesof algal secondarytreatment and lagoonprocessusingbacteriafor nutrientremoval.

2. Materials and methods

2.1. Experimental site and wastewater

The studywascarried out at a domestic WW treatment plantsituated in the northeast of the Capital of Ouargla, Algeria (geographiccoordinates: latitude: 31°59’46, 23 ‘’ N; Longitude:5°21’55, 77’ E). Theexperimentswerecarried out in the winterperiodusing sunlight as a light source. The temperaturesrangedbetween 18 and 31 °C during the day and 6–15 °C at night. The duration of insolation duringthisseasonwasapproximately 9 ha day (7 a.m._5 p.m.); the maximum irradiancewasapproximately1100 W/m^2. This wasmeasuredusing a solarimeter (SL200, KIMOinstrument, France). The WW used in thisstudywasobtaineddirectlyfrom the aeratedlagoon station basins afterprimaryscreening. The characteristics of the raw WW (RW) are summarizedin Table 1.

Table 1. Wastewater characteristicbefore/afteralgae and lagoonprocesstreatment

Characteristics	Raw WW	Algae treated WW	Lagoon treated WW
pH	7.82	9.36	7.43
Dissolved oxygen (mg/l)	0.2	9.4	4.5
Conductivity (mS/cm)	7.97	10.88	10.99
Salinity (g/l)	4.4	6.1	6.8
COD (mg/l)	426	90	110.75
NH_4^+–N (mg/l)	46.2	2.1	32
TP (mg/l)	3.22	0.596	2.41
NO_3^--N (mg/l)	1.156	16.9	0.57

3. Results and discussion

3.1. Algal growth in wastewater

From the WW characteristics (Table 1), itcanbeseenthat theamount of nutrientelements in WW is more thanthat of the preparedBG11 medium. The WW containsabundant N, available asNO_3-N (1.15 mg/L) and NH_4-N (46.2 mg/L) and P as TP (3.22 mg/L).The variation of temperatureduring the experimentrangedbetween 18 and 31°C (Fig. 1). Zhao et al. (2015) showedthatata temperature of 35 °C, C. pyrenoidosawas able to achieve a biomassproductivity of 0.16 g/L.d.From Fig. 1 itcanbeseenthatthe maximum temperatureduring the culture periodreached ashigh as 31 °C. This canbeconsideredlowwhencompared to otherseasons. During the summer (July–August) the temperaturecanreach 50 °C. The latitudes and the absence of couldcoveris thedesert area let the annuallevels of solar radiation significantlyhigherthan in other areas. High and uniform incident irradiancelevelspresent an advantage for microalgalcultivation by increasingthe photosynthetic active radiation (PAR) (Garcia-Gonzálezet al., 2003), whichrepresentaround 43% of the solar radiation.

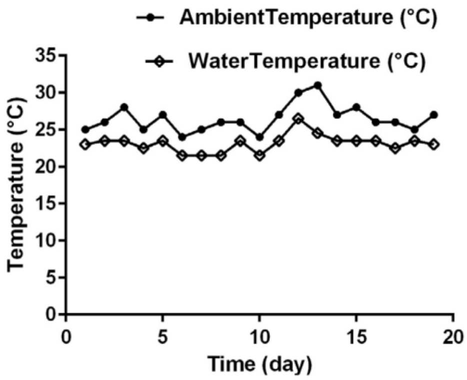

Fig. 1. Ambient and water temperatureduring the culture period

At the start of the experimentation, the pH was 7.8 (Fig. 2). Thisgraduallyincreased to 9.2. This wasmostlyrelated to photosyntheticactivity. As microalgae use CO2, the pH increasesfromacidicto alkaline due to the CO2 depletion. The pH optimum for mostalgae range between 7 and 12.Fig. 2 shows the variation of the DO during the experimentalperiod. It canbeseenthat the lowest DO was on day 1. This waspotentiallyattributed to organismssuch as bacteriathatrequiredthe DO to decomposeanyorganicmaterial in the WW.

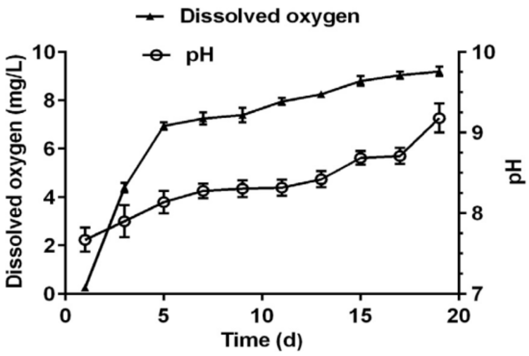

Fig. 2. Dissolvedoxygen and pH variation during the culture period.

It thenincreasedgradually to an approximate concentration of 8 mg/Lduringthe cultivationperiod. From the results, itcanbeseenthatthe microalgalgrowthincreasewith DO. Microalgaeperformphotosynthesisin whichthey release DO into the culture medium. Asthe culture densityincreasedtherewas an increase in the DOlevels in the medium.

4.conclusion

The chlorellastraintestedwas able to growsatisfactorily in pretreatedwastewater.Theexperimentalresultsindicatedthat*Chlorella*has potential to remove CODconcentration, ammonium and total phosphorusat a reasonableuptake rate fromwastewaterwhilebeingcultivatedusingwastewater as a culture medium.

The nutrientremovalefficiencieswere 78% (COD), 95% NH_4^+-N and 81% (TP). The results in thisstudyshowedthatchlorellacultivation in wastewateris apromisingmethod to produce algal biomass in addition to nutrientsremoval.

5.References

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