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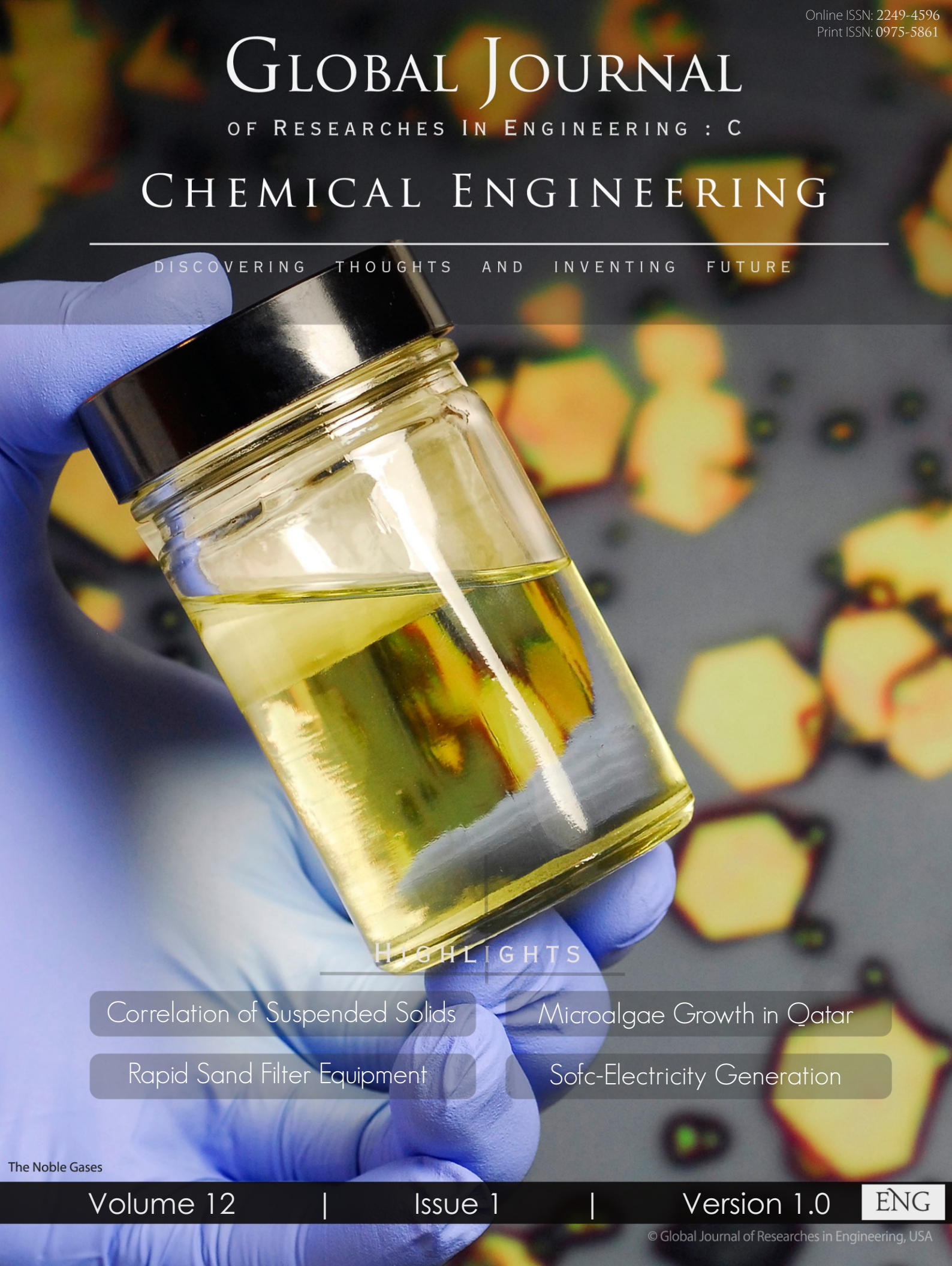

Highlights

- Correlation of Suspended Solids
- Microalgae Growth in Qatar
- Rapid Sand Filter Equipment
- Sofc-Electricity Generation

The Noble Gases

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Microalgae Growth in Qatar for CO2 Capture and Biodiesel Feedstock Production

By Rebecca J. Wilson, Ghada Salama & Ihab H. Farag
University of New Hampshire, Durham

Abstract - Demands for and prices of liquid petroleum fuels are increasing. This challenge is motivating the development of alternative fuels, like biodiesel from non-food sources. Microalgae are a promising source of oil feedstock for biodiesel. Growing microalgae indoors uses water, chemical nutrients, artificial lights, and energy for harvesting, drying and oil extraction. The economics would be greatly improved if microalgae are grown outdoors in a hot sunny climate where the light energy is free and the temperature is adequate for growth. Using non-potable water (such as available and free salt-water) would reduce the water footprint. Open pond systems have low capital and operating costs and are wellsuited for growing microalgae in salty water. The ideal location for growing microalgae outdoors is a non-arable land that cannot be used for agriculture (such as Qatar desert). The purpose of this research is to study the growth of salt-water microalgae outdoors in Qatar's hot sunny environment and compare it to indoor growth. Three Dunaliella microalgae (Bardawil, Parva and Salina) were grown in Persian Gulf saltwater medium.

Keywords : *Biodiesel, microalgae harvesting, Qatar, lipid production, hot climate.*

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Microalgae Growth in Qatar for CO_2 Capture and Biodiesel Feedstock Production

Rebecca J. Wilson [α], Ghada Salama [σ] & Ihab H. Farag [ρ]

Abstract - Demands for and prices of liquid petroleum fuels are increasing. This challenge is motivating the development of alternative fuels, like biodiesel from non-food sources. Microalgae are a promising source of oil feedstock for biodiesel. Growing microalgae indoors uses water, chemical nutrients, artificial lights, and energy for harvesting, drying and oil extraction. The economics would be greatly improved if microalgae are grown outdoors in a hot sunny climate where the light energy is free and the temperature is adequate for growth. Using non-potable water (such as available and free salt-water) would reduce the water footprint. Open pond systems have low capital and operating costs and are well-suited for growing microalgae in salty water. The ideal location for growing microalgae outdoors is a non-arable land that cannot be used for agriculture (such as Qatar desert). The purpose of this research is to study the growth of salt-water microalgae outdoors in Qatar's hot sunny environment and compare it to indoor growth. Three Dunaliella microalgae (Bardawil, Parva and Salina) were grown in Persian Gulf saltwater medium. A fish tank photobioreactor was used to simulate an open pond. Dunaliella Bardawil provided the highest microalgae oil feedstock for biodiesel production, with a production rate of 20 mg dry algae/L-day, an oil content of 5.7 g oil/100 g dry algae, and oil production rate of 1.14 mg oil/L-day. The operation had a carbon sequestration efficiency of 6.5% and a photosynthetic efficiency of 1.11%. Among the algae tested, Dunaliella Bardawil is the optimal candidate for growth in Qatar conditions using an open pond system.

Keywords : biodiesel, microalgae harvesting, Qatar, lipid production, hot climate.

I. Introduction

a) Biodiesel

Biodiesel is a plant-derived biofuel intended to replace petroleum diesel. It is biodegradable, essentially CO_2 neutral, and much less toxic than petro diesel. It is made in a processor (Wilson and Farag, 2012) by the transesterification of a triacylglycerides (TAGs)-containing oil feedstock (e.g., oils of soybean, rapeseed, maize and Jatropha, Tewfik et al., 2012) and an alcohol (e.g., methanol or ethanol). One of the very promising oil feedstocks for biodiesel is microalgae oil (Nkongolo, 2010, Nkongolo and Farag, 2012, Chaput et al. 2012, Zuka et al., 2012).

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b) Microalgae

Microalgae are plant-like cells. They require a nutrient medium (water + nitrogen + phosphorous + other nutrients), CO_2 and light energy to do photosynthesis and grow. The simplest technique to grow microalgae in hot sunny areas like Qatar is in open ponds. During photosynthesis the algae capture the light energy and use it for carbon fixation, i.e., convert CO_2 (absorbed from air or water) to glucose and release oxygen. Up to 50% is converted into TAG-containing lipids (oil) that can be used as a biodiesel feedstock in the transesterification reaction (Scott, 2010). Table 1 shows that microalgae, e.g., Nannochloropsis or Chlorella, have the potential to produce more oil feedstock for biodiesel than other crops. This is due to the simple cell structure and surface water interface. Algae cells have efficient and easy access to dissolved CO_2 and other nutrients while growing suspended in water. Hence algae are considered excellent CO_2 capture and use (CCU) systems. Estimates are that 2.5 tonnes of CO_2 are needed to produce 1 tonne of microalgae and one tonne of oxygen. Assuming 50% oil content in the dry algae the 1 tonne algae can produce roughly 3.5 barrels of biodiesel (Kanes, 2009). CO_2 produced in the cement industry or in coal fired power plants can be used to fertilize the microalgae production (Chaput et al., 2012). The consumption/fixation of CO_2 takes place during daylight when exposed to the sun, hence it depends on light exposure. It has been reported that over a seven day growth period the microalgae removed 82% of CO_2 on sunny days (such as Qatar sunny weather), and 50% on rainy days. Microalgae can consume nitrogen sources 24 h/day. Testing over a seven day period showed that microalgae removed 86% of NOx with or without light. Microalgae as a feedstock for biodiesel will not compete with food crops because they can be grown on non-arable land (such as Qatar desert).

Table 1: Estimation of oil productivity from various crops (Scott 2010, Mulumba, 2010 and 2012)

Crop	Oil content per ton of biomass (wt% dry mass)	Oil production (Mton/ha-y)
Rapeseed oil (UK)	40-44% (of seed)	1.4
Soyabean	20% (of seed)	0.48
Jatropha	30% (of seed)	2.4
Chlorella vulgaris	Up to 46%	7.2*
Nannochloropsis	Up to 50%	20-30*

*Assumed productivity

c) Photosynthetic Solar Constant

The photosynthetic solar constant, which is the yearly mean solar irradiance on the surface of the earth oriented towards the sun above the atmosphere, is 1340 W/m^2. The photosynthetic active region range is 40-750 nm (Agrawal, 2010). This provides 26% of the standard solar constant or 350 W/m^2 of input power to the photosynthetic process. The theoretical maximum photosynthetic efficiency is 20% (Bonner, 1962). Thus, the photosynthetic solar constant, or the maximum output power that can be achieved under ideal conditions would be 70 W/m^2. The solar biomass constant or theoretical upper limit on the equivalent biomass harvested would be 4.5 mg/m^2-s.

d) Cost Estimates of Algae Production

There are three main factors that affect the production cost of algae: (1) cost of land used for the algae production facility, (2) the value of the by-products of algae growth and oil extraction, and (3) the algae oil production rate (g oil/L-day) and hence the importance of this investigation. For open pond algae production systems the capital costs estimates range is $50,000 to $250,000 per hectare, and the operating costs are about $15,000 to $20,000 per hectare per year. The almost free desert land in Qatar will lower the capital costs estimates. The results of this investigation of using Qatar's hot sunny climate to grow and dry the algae should lower the annual production costs.

II. Goals and Specific Objectives

The goal of this research is to investigate the feasibility of producing microalgae oil in Qatar to be used as biodiesel feedstock. To accomplish this goal, the specific objectives were to:

- Study algae oil production in an open pond system in Qatar's hot sunny desert climate.
- Identify if nutrients should be added to the Gulf (off Qatar) seawater to favor algae oil production.
- Compare different algae strains to determine the most favorable for algae oil biodiesel feedstock production.

a) Open Pond System

The design of the photobioreactor (PBR) is very important in scaling up the growth of microalgae in Qatar's hot sunny desert climate. Open ponds are inexpensive PBRs and easily maintained, but may suffer from contamination. This is less likely in Qatar due to the high salinity of the Gulf seawater. Open ponds have to be shallow to allow for sunlight penetration. Hence a large surface area is needed, which makes harvesting more difficult (Scott, 2010). Fish tanks with sides blacked out simulate a shallow open pond with a large surface area.

b) Qatar

Microalgae were grown outdoors in Doha, Qatar during the summer of 2011. This climate provides constant daylight, averaging 95,000 lux (139 W/m^2) (Hoki, 1999) whereas the average outdoor daylight in the USA is 50,000 lux or 73 W/m^2. Qatar is an excellent candidate for growing microalgae because of its high light intensity, desert land, location and CO_2 emissions. Qatar's sunlight intensity will enhance algae photosynthesis. Only 6% of Qatar is agricultural land, so there is plenty of desert land that could be used to grow algae. Qatar is located in the Gulf, which provides easy access to salt water and is a source of microalgae. Qatar has the highest per capita CO_2 emissions in the world (55.4 tonnes vs. 20 in the US in 2007) due to the petroleum and cement industries. Algae growth is an excellent method of CCU, so Qatar is an ideal candidate for algae growth.

c) Microalgae Strains

Microalgae growth in batch cultures occurs in the following phases: lag, exponential, stationary and death. Ideally, the microalgae should be harvested in the stationary phase because they have reached maximum growth, and the nutrients will have been used up so the microalgae start to accumulate lipids. There are four classes of microalgae; diatoms, green algae, blue-green algae and golden algae (Kanes, 2009). Green algae, e.g., Dunaliella, were used in the present study because they can grow in fresh water and in salt water (such as Gulf seawater). Also, Dunaliella microalgae are the most halotolerant species known and are more tolerant of fuel oil contamination than other species (Tafreshi. 2009). Three specific strains of Dunaliella microalgae were used in the present work: Salina, Bardawil and Parva. These strains were chosen for their ability to thrive under hot temperatures in saline water, and their high lipid content (Table 2) ((Abd El-Baky (2004), Peeler (1989), Tafreshi (2009), Scott (2010), Fried (1982), Ben-Amotz (1990), Evans (1982)). The selected strains were all grown in an open pond system in Doha, Qatar to select the species that exhibits growth, biomass production and oil content.

Table 2 : Optimal growth conditions and lipid content

Duna-liella Species	Temp (°C)	Salinity (M NaCl)	Lipid(% dry algae mass)	Found in Gulf salt water?
Salina	22-35	0.9-4.3	50	Yes
Bardawil	25	3.0-4.0	30	Yes
Parva	32	1.5-2.0	21-25	Unknown

III. Approach & Metrics

a) Experiment Layout

The experimental work, summarized in Table 3, was done in two phases. The first was to provide enough algae for outdoor testing and establish baseline data on the performance of microalgae in Gulf seawater. These experiments were done indoors using fluorescent lights (4 bulbs illuminating seven 500 mL PBRs) and artificial (contaminants-free) salt water. The second phase aimed at more realistic tests of growing the microalgae in Gulf seawater exposed to Qatar's sunlight and hot climate. This was done outdoors on the roof of a building. The algae growth period for each run was about 14 days. All runs were done in batch mode, i.e., the medium (Gulf seawater with or without nutrients) was placed in the PBR, algae inoculum was added and the air flow was started. Air use had the dual purpose of supplying the CO_2 required for algae growth and oil formation, and providing algae and nutrient medium mixing. Once the algae growth reached the stationary phase they were harvested and dried, then the algae oil was extracted.

Table 3 : Experimental Steps

Step	Medium	Lighting	Explanation
Phase 1			
1- Inoculum Growth for future runs.	Artificial sea water	Fluorescent 24 h/d	Grow inoculum indoors.
2- Indoors Algae Growth	Gulf salt water	Fluorescent 24 h/d	without and with nutrients.
3- Indoors non-algae Growth (with and without nutrients)	Gulf salt water - no algae	Fluorescent 24 h/d	Monitor Gulf sea water without algae to check for competing species.
Phase 2			
4- Growth outdoors in a fish tank PBR with added nutrients.	Artificial sea water and Gulf salt water	Sunlight (9 hours/day)	Measure solution absorbance daily.
5- Algae harvesting			Stationary phase
6- Algae dewatering and outdoor drying using sunlight		Sunlight (9 hours/day)	Centrifuge algae to a slurry. Dry outdoors to get dry algae.
7- Hexane extract oil then evaporate hexane			Solvent extract the lipids/oil from algae produced.

b) Analytical Procedures and Metrics

Nitrate and pH measurements are important to maintain a consistent growth environment. This was done by collecting 5 mL of algae solution daily and using Mardel test strips. Algae growth was monitored daily by measuring the algae solution absorptivity at 680 nm. This was done by placing the same 5 mL solution in a DR2800 Spectrophotometer. Table 4 lists the measured variables and the metrics calculated.

Table 4 : Measured Variables and Metrics

Measurement	Purpose/ Metrics
Algae solution absorbance, DR2800 Spectrophotometer	Algae growth, from absorbance/ turbidity
Acidity of solution (pH), nitrite and nitrate levels with Mardel test strips.	Nutrient content, depletion or starvation
Algae mass after harvesting and drying (using a balance)	Algae production rate (g dry algae/L-day)
Mass of algae oil after extraction	Algae oil yield (g oil/100 g dry algae)
Air flow rate, liters/min (using a rotameter)	Carbon sequestration/capture efficiency
Incident light intensity with a light meter, Lux.	Photosynthetic efficiency

c) Data Analysis/Calculated Indicators

The performance of the PBRs was established by calculating the indicators explained in Table 5.

Table 5 : Performance Parameters and Definitions

Parameter	Definition/How Calculated
Photosynthetic Efficiency or Light Capture Efficiency is the light energy transferred through PBR and converted to biomass	Ratio of the energy produced by the combustion of the algae to the incident light energy produced by the artificial lights used.
Carbon Sequestration/Capture Efficiency is the mass of C sequestered by the algae relative to the C supplied to the microalgae.	C in dry algae formed/ Total C from the air into the PBR during growth, assuming: -Constant air flow rate - Air CO2 (394 ppmv) is the only C source for algae. -Dry algae are 60.4% C, based on literature.

IV. Methodology

a) Algae Growth and Monitoring

i. *Algae Inoculum Growth*

The algae inoculum was grown indoors in distilled water using 1.5 M NaCl, macro and micronutrients- this growth media is called "artificial seawater". The measured light intensity of 86,400 lux= 362.9 W/m^2 = photosynthetic photon flux density (PPFD) or light intensity of 1451.5 µmol/m^2s^{-1}. The carbon source was an air feed from a fish tank air pump.

ii. *In Lab/Indoor Microalgae Growth*

Once algae inoculum had grown, the in lab salt water trials were set up (Table 6).

Table 6 : Algae species/ nutrients for different in-lab trials.

Trial Name	Algae Species	Nutrients
Bardawil-SWN	Dunaliella Bardawil	Yes
Bardawil-SW	Dunaliella Bardawil	No
Parva-SWN	Dunaliella Parva	Yes
Parva-SW	Dunaliella Parva	No
None-SWN	None	Yes
None-SW	None	No

Algae were grown in either just Gulf seawater, or Gulf seawater with added nutrients. The purpose was to determine how the algae would grow in the Gulf seawater, if nutrients are needed, and the species that grew best. Trials without microalgae were included to measure the growth rate of other species in the Gulf seawater. Each trial was exposed to a continuous (24 hour/day) air feed and fluorescent lights.

iii. *Outdoor Algae Growth*

Algae were grown outdoors in fish tanks with the sides blacked out so only sunlight would enter from the top. The growth medium had the same salinity as the Gulf seawater (40 g salt/L water), same airflow rate and natural sunlight. Nutrients were added in the same proportions as the algae inoculum growth. Two trials were set up: 20 L Dunaliella Bardawil and 20 L Dunaliella Salina (the results from the indoor lab tests indicated that the Dunaliella Parva does not grow well in the Gulf seawater, so it was not grown outdoors).

Algae were also grown using the Gulf seawater with the same nutrients, airflow and natural sunlight. Two trials were set up:10 L Dunaliella Bardawil and10 L Dunaliella Salina.

b) Algae Harvesting

Algae were dewatered by centrifuging the solution at 5000 RPM for 6 minutes. The saltwater was then removed and DI water was added to clean the algae of salt and the algae were centrifuged again (5000 RPM, 6 minutes). During centrifugation, the algae were completely removed from the water, but the salt remained dissolved in the DI water. This cleaned the algae, and the discarded water did not contain any algae. The algae were dried using natural sun heat by placing the dense algae slurry outdoors (2 hours). The dry algae were massed, then mixed with hexane, heated, and the evaporated hexane was condensed and reused. Over a period of time (2 hours) the hexane extracts the oil in the algae. The algae biomass is removed by vacuum filtration. The filtration was repeated at least four times, or until the filter paper no longer retained algae. Oil is recovered by evaporating the hexane using a hot water bath.

V. Results/Accomplishments

a) Indoor Algae Growth and Monitoring Results

Figure 1 shows the growth measurements of the six different tests of Table 4. The standard trials show very little growth, indicating there was not a strong presence of competing species. During the lag phase there was similar growth in all the microalgae species, but when they reached the exponential phase, the

Dunaliella Bardawil grown with nutrients in Gulf seawater clearly grew the best. The Bardawil without nutrients showed little growth, and both Parva samples had little growth as well. Due to the poor growth of the Parva, they were excluded from further testing. Instead, it was determined that the Bardawil should be grown outdoors in both artificial seawater and Gulf seawater solutions containing nutrients. Table 2 indicates that Dunaliella Salina is promising, so though no indoor testing was performed, Salina was grown outdoors using the same conditions as Bardawil.

b) Outdoor Algae Growth and Monitoring Results

Figure 2 shows the four outdoor growth runs. It is evident that the trials in artificial seawater had a much longer lag phase than the trials in the Gulf seawater. This could be because the Gulf seawater has its own additional nutrients that expedite the growth of the microalgae. The Dunaliella Bardawil appears to exhibit consistently better growth than the Dunaliella Salina, shown by the higher final absorbance.

c) Algae Harvesting

After harvesting, the algae are massed to determine the production rate, the carbon sequestration and photosynthetic efficiencies. Lipids are extracted to get the algae oil content and the oil production rate.

The algae production rate was calculated for the four outdoor trials done in artificial seawater or Gulf seawater with nutrients. The results in Figure 3 indicate that the Dunaliella Bardawil shows the highest production, both in artificial seawater (using DI water and nutrients) and in the Gulf seawater off the coast of Qatar. The Dunaliella Salina grew well in the artificial seawater, but there was very little algae production in the Gulf seawater. This indicates that among the algae strains investigated, Bardawil has the highest growth rate in the Gulf seawater with nutrients. The algae production of Bardawil in artificial seawater is 0.02 g/L-day. This is equivalent to about 1.67 g/m^2-day or 0.0192 mg/m^2-s. This is less than 1% of Agrawal theoretical upper limit of biomass harvested of 4.5 mg/m^2-s. The daily algae production rate of 1.67 g/m^2-day is lower than the 12 g/m^2-day reported for Dunaliella Salina in Oilgae.com indicating the possibility of further improvement in the algae production.

Figure 4 shows the algae oil content results. Dunaliella Salina grown in the artificial seawater with nutrients had the highest oil content. The Dunaliella Bardawil grown in both the artificial seawater and the Gulf seawater had similar oil content. This is indicative that the Gulf seawater provides an environment similar to the artificial seawater, and the microalgae are able to produce oil as usual.

The oil production rate of the microalgae is the final oil mass per liter of initial solution per day of growth.

Figure 5 shows that all three trials were within the same range of oil produced. This further confirms that algae oil as a biodiesel feedstock, can be produced by growing Dunaliella Bardawil in the Gulf seawater.

The carbon sequestration efficiency and the photosynthetic efficiency of the microalgae were calculated for the outdoor trials of Dunaliella Salina and Dunaliella Bardawil. Table 7 shows that the carbon sequestration efficiency of the microalgae was between 3-6.5%. The photosynthetic efficiency of the microalgae ranged from 0.053-1.11%.

Table 7 : Carbon sequestration and photosynthetic efficiencies

Dunaliella Algae grown outdoors with Nutrient	Carbon Sequestration Efficiency* (%)	Photosynthetic Efficiency (%) **	Photosynthetic Efficiency relative to the photosynthetic solar constant (%) ***
Salina- DI water	6	0.6	1.1
Bardawil- DI water	6.5	1.11	2.1
Bardawil- Gulf saltwater	3.1	0.053	0.1

*Based on 60.3% carbon by mass in the microalgae, and 394 ppmv CO2 in the air
**Based on microalgae heating value of 5000 cal/g and incident light of 89,000 lux, or 130 W/m^2
*** Based on Agrawal constant of 70 W/m^2

These efficiencies are lower than the typical range of photosynthetic efficiency of microalgae. A possible explanation is that the only mixing of the algae was from the air supply bubbling through the solution. This prevents the algae at the bottom of the tank from receiving light as the solution becomes more concentrated with algae, and this will decrease the photosynthetic efficiency. It is evident that the Dunaliella Bardawil grown in DI water with nutrients had the highest photosynthetic efficiency (1.11%) and carbon sequestration efficiency (6.5%). Table 8 compares the present work results and literature values. The results confirm the feasibility of producing microalgae oil biodiesel feedstock in Qatar and that the process may be further improved.

Table 8 : Comparison of present Dunaliella results and literature (DI = DI water, GS = Gulf seawater)

Parameter	Present work: algae /medium	Literature Value
Photosyn-thetic efficiency	Bardawil/ DI1.1% Bardawil/GS 0.053% Salina/DI 0.6%	3.78% (Zemke, 2008)
Carbon Seques-tration Efficiency	Bardawil/DI 6.5% Bardawil/GS 3.1% Salina/DI 6.0%	12%
Biomass concentra-tion g Dry algae/L	Bardawil/DI 0.48 Bardawil/DI 0.17 Salina/DI 0.2	0.5 (Chisti, 2007)
Final Lipid production mg oil/L	Bardawil/DI 28 Bardawil/GS 9 Salina/DI 20	1420 (Li, 2011)

VI. Conclusions

Dunaliella Bardawil showed better algae production and slightly higher carbon sequestration and photosynthetic efficiencies than Dunaliella Salina and Parva. But Salina accumulated higher oil content per algae biomass. The present work demonstrates that Dunaliella Bardawil and Salina have potential for larger scale microalgae oil production in the hot sunny climate of Qatar using the Gulf seawater off Qatar

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References Références Referencias

1. Abd El-Baky, H.H, F.K. El Baz., and G.S. El-Baroty "Production of Lipids Rich in Omega 3 Fatty Acids from the Halotolerant Alga Dunaliella Salina." *Biotechnology (Faisalabad)* 3.1 (2004): 102-08
2. D. C. Agrawal, D.C. "Photosynthetic Solar constant," Lat. Am. J. Phys. Educ. Vol. 4, No. 1, Jan. 2010
3. Ben-Amotz A, Ginzburg BZ. Light-induced proton uptake in whole cells of Dunaliella parva. Biochim Biophys Acta. 1969 Jun 3; 183(1):144-54.
4. Ben-Amotz, Ami, and Mordhay Avron. "On the Factors Which Determine Massive Beta-Carotene Accumulation in the Halotolerant Alga Dunaliella Bardawil." *Plant Physiology* 72 (1983): 593-97. Print.
5. Ben-Amotz, Ami and Mordhay Avron. "The Biotechnology of Cultivating the Halotolerant Alga Dunaliella." *Tibtech* (1990): 8, 121-126.
6. Bonner, James, "The upper limit of crop yield, "Science 137, 11-15 (1962).
7. Chaput, Gina, Charmanski, Kyle, Farag, Ihab (2012) "Sustainable Production of Microalgae Oil Feedstock Using Municipal Wastewater and CO2 Fertilization", International Journal of Engineering Science and Technology (IJEST), Vol. 4, No. 7, July 2012, p 3491-3501, ISSN : 0975-5462.
8. Chisti, Y., "Biodiesel from microalgae," Biotechnology Advances 25, 294-306 (2007).
9. Evans, R.W., M. Kates, M. Ginzburg, and B.-Z. Ginzburg. "Lipid Composition of Halotolerant Algae, Dunaliella Parva Lerche and Dunaliella Tertiolecta." *Biochimica Et Biophysica Acta (BBA) - Lipids and Lipid Metabolism* 712.1 (1982): 186-95.
10. Fried, Adina, Alisa Tietz, A. Ben-Amotz, and W. Eichenberger. "Lipid Composition of the Halotolerant Alga, Dunaliella Bardawil." *Biochimica Et Biophysica Acta (BBA) - Lipids and Lipid Metabolism* 713.2 (1982): 419-26.
11. Kanes, S (2009), "The Choice of Next-Generation Biofuels," Equity Research Industry Report, Scotia Capital.
12. Hoshi, Takehiko (1999), "The unit concerning the light in the plant production", Tokai University, http://www.fb.utokai.ac.jp/WWW/hoshi/env/light.html
13. Li Y, Chen YF, Chen P, Min M, Zhou W, Martinez B, Zhu J, Ruan R. (2011),"Characterization of a microalga Chlorella sp. well adapted to highly concentrated municipal wastewater for nutrient removal and biodiesel production'" Bioresoure Technol. 2011 Apr;102(8):5138-44. Epub 2011 Feb 24. PubMed PMID: 21353532.
14. Mulumba, N. (2010) "Production of Biodiesel from Microalgae," M.S. Thesis, (Advisor I.H. Farag), Chemical Engineering Dept., University of New Hampshire.
15. Mulumba, N. and Farag, I.H., (2012)," Tubular Photobioreactor for Microalgae Biodiesel Production," (IJEST), Vol. 4 No. 02 February 2012, pp 703-709.
16. Peeler, T. C., M. B. Stephenson, K. J. Einspahr, and G. A. Thompson. "Lipid Characterization of an Enriched Plasma Membrane Fraction of Dunaliella Salina Grown in Media of Varying Salinity." *Plant Physiology* 89.3 (1989): 970-76.
17. Scott, Stuart A., Matthew P. Davey, John S. Dennis, Irmtrau Horst, Christopher J. Howe, David J. Lea-Smith, and Alison G. Smith. "Biodiesel from Algae: Challenges and Prospects." *Engineering Village*. Compendex, June 2010.
18. Tafreshi, Hosseini A., and Mansour Shariati. "Dunaliella Biotechnology: Methods and Applications." *Journal of Applied Microbiology* 107 (2009): 14-35.

19. Tewfik, S., S. Hawash, N. Atteya, G. El Diwani, and I.H. Farag (2012). "Techno-Economic Appraisal of Biodiesel from Jatropha Curcas: An Egyptian case study," J. Agricultural Science and Technology (JAST) B 2 (2012) 287-297
20. Wilson, R. and I.H. Farag (2012). "Parametric Study of Biodiesel Quality and Yield Using a Bench-Top Processor." International Journal of Oil, Gas and Coal Technology 5(1): 92-105.
21. Zemke, P, B Wood, and DDye, "Technoeconomic Analysis of Algal Photobioreactors for Oil Production," Workshop on Algal Oil for Jet Fuel Production, February 2008, the National Renewable Energy Laboratory (NREL).
22. Zuka, Z, B. McConnell, I.H. Farag. Comparison of Freshwater and Wastewater Medium for Microalgae Growth and Oil Production. Journal of American Science 2012; 8(2):392-398.

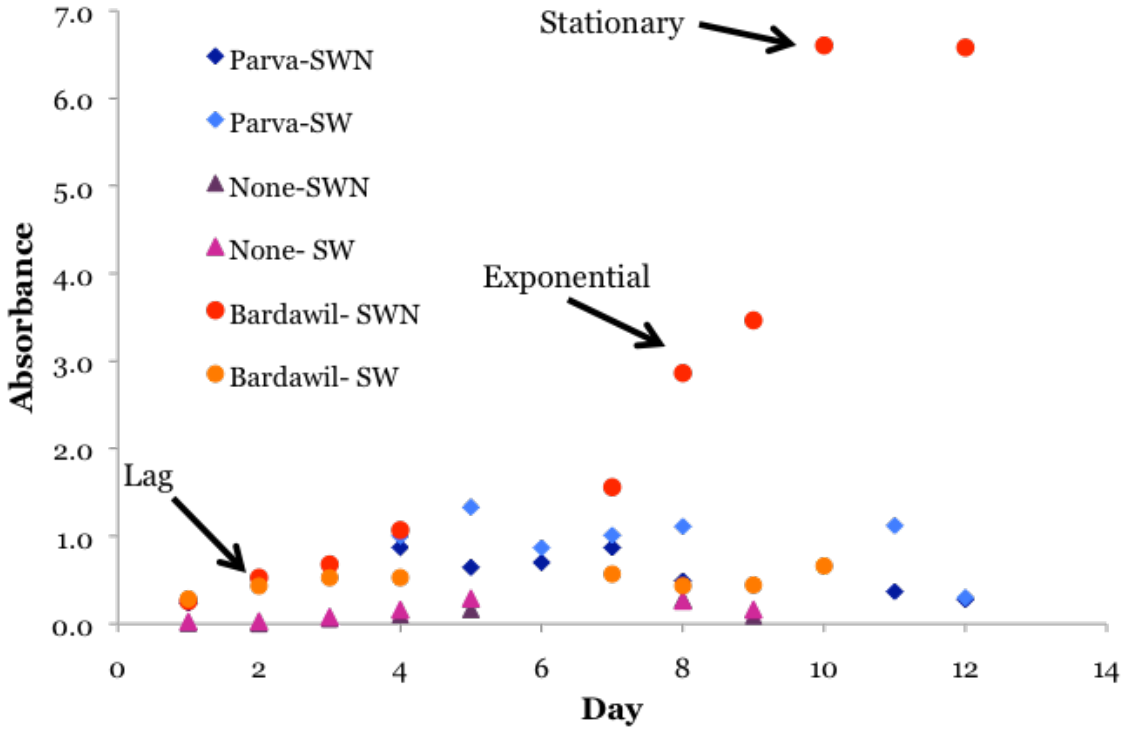

Figure 1 : Indoor salt water trials absorbance measurements (absorbance vs. time in days).

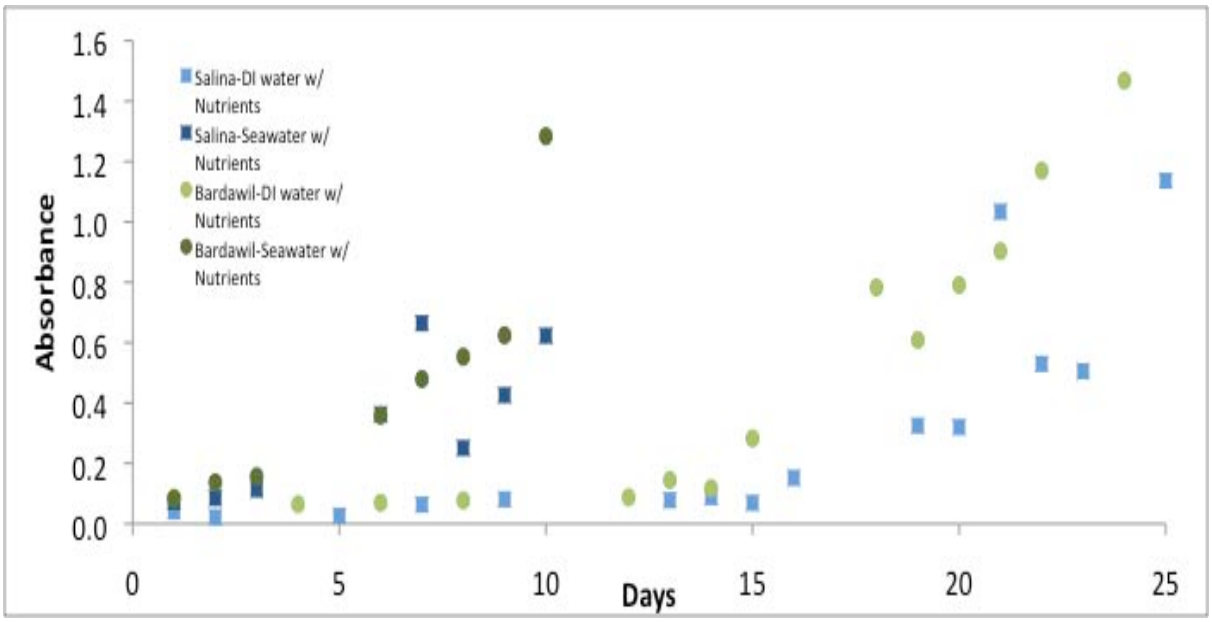

Figure 2 : Outdoor salt water trials absorbance measurements.

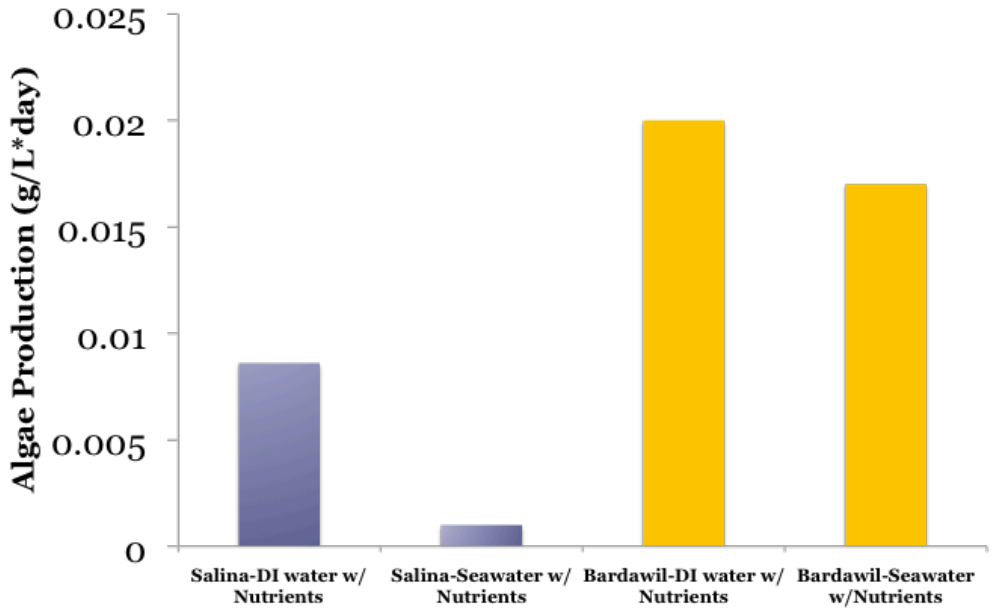

Figure 3 : Algae production (grams per liter per day, or simply g/L-day) of Dunaliella Salina and Dunaliella Bardawil grown outdoors.

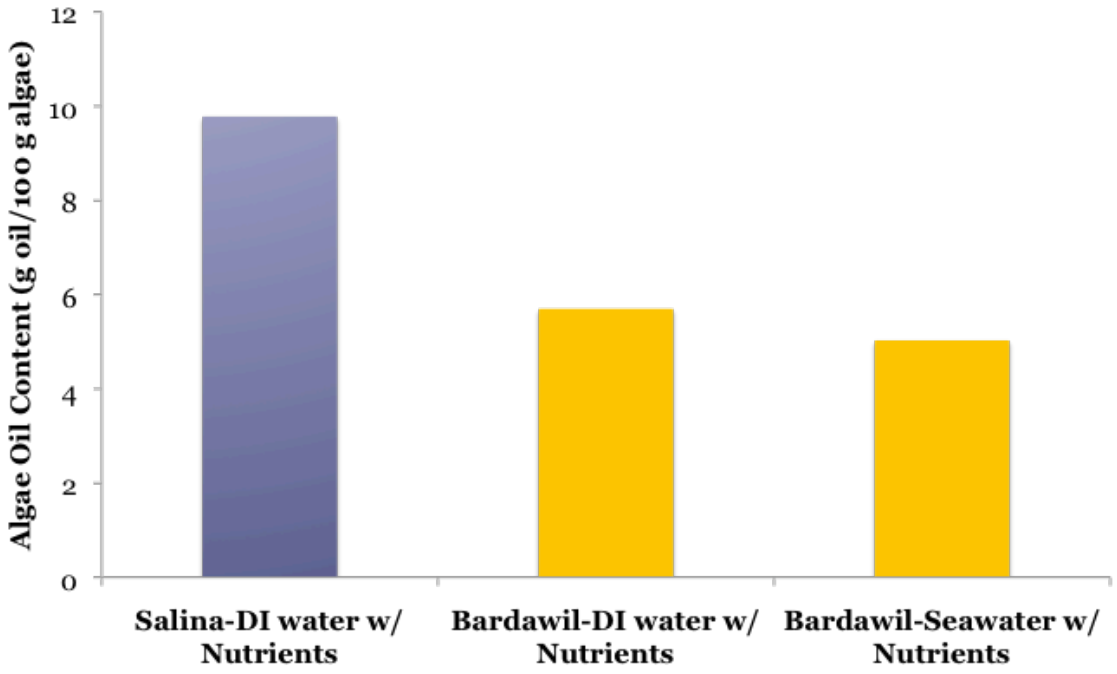

Figure 4 : Algae oil content (g oil/100 g algae) of Dunaliella Salina and Dunaliella Bardawil grown outdoors.

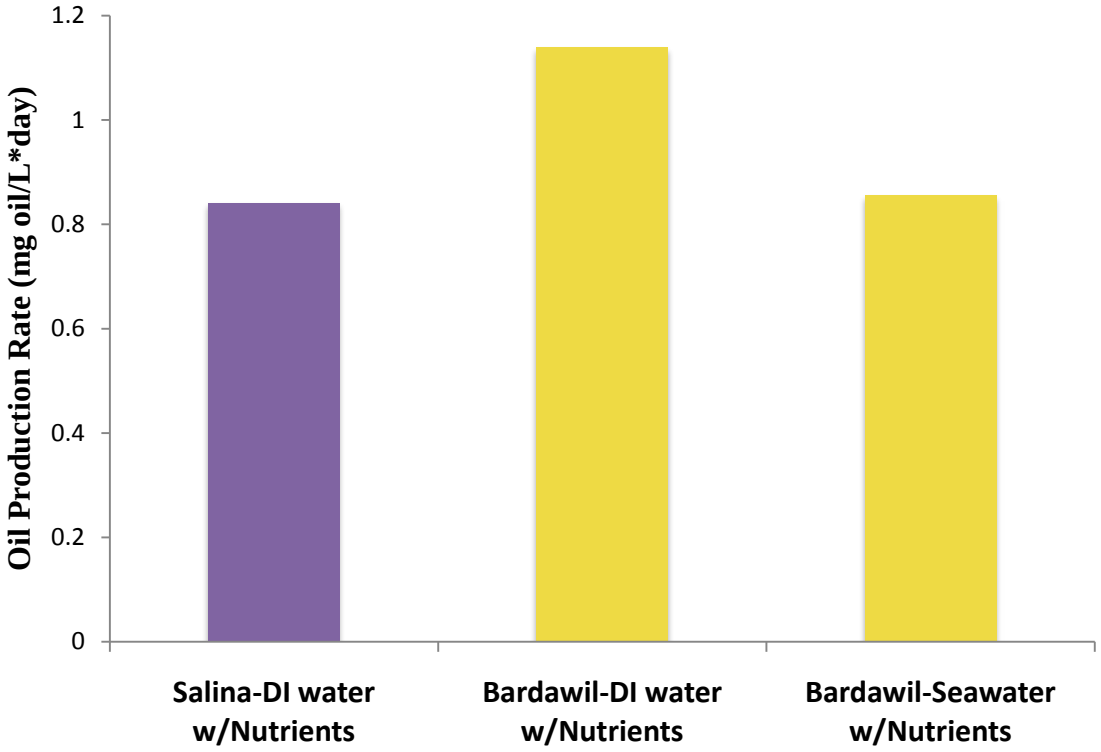

Figure 5 : Oil production rate of algae (mg oil/L solution -day) in Dunaliella Salina and Dunaliella Bardawil grown outdoors.

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Effect of KCL on Rheological Properties of Shale Contaminated Water-Based MUD(WBM)

By Joel, O.F, Durueke, U.J & Nwokoye C.U

University of Port Harcourt, Nigeria.

Abstract - Interests in the design of water-based muds(WBM) have escalated due to wellbore instability issues that arise from the abundance of problematic shales encountered while drilling. Conventional water-based muds(WBMs) that are used to drill through water sensitive shale formations cause a high degree of wellbore instability. Consequently, oil based muds(OBMs) were adopted to solve the wellbore instability problems due to their superior shale stabilization properties. Unfortunately, high costs, environmental restrictions, cuttings and used mud disposal difficulties and safety have largely limited the use of OBMs. As a result of these challenges with OBMs, WBMs that have the ability to effectively reduce shale instability problems have once again come under the lime light to replace the OBMs. Potassium-based (KCL)muds are used in areas where inhibition is required to limit chemical alteration of shales. This research study therefore was undertaken to evaluate the inhibition effects of different concentrations of KCL on the rheological properties of water-based mud(WBM) contaminated with shale.

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Joel, O.F [α], Durueke, U.J [σ] & Nwokoye C.U [ρ]

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I. Introduction

The art and science of drilling wells require the use of drilling fluids for several reasons including cuttings carrying and maintenance of wellbore stability. Drilling fluid selection is dependent on the behaviour of the formation to be drilled. Shale, the most abundant rock type in the earth interacts variably with the fluids used. Shales are low-permeability sedimentary rocks with small pore radii that characterized by low permeability, medium to high clay content, and medium porosity in addition to other minerals, such as quartz, feldspar, and calcite. Shale types range from soft Gumbo shale in offshore Louisiana, Gulf of Mexico to hard brittle shale in South Louisiana with each type presenting its own set of problems. They account for over 75% of formations drilled all over the world and cause over 90% of wellbore instability problems. The distinguishing features of shale are its clay content and low permeability, which results in poor connectivity through narrow pore throats. Shales are also fairly porous and are normally saturated with formation water, with several factors affecting their properties, such as burial depth, water activity, and the amount and type of minerals present(Joel, et al).

Interests in the design of water-based muds (WBM) have escalated due to wellbore instability issues that arise from the abundance of problematic shales encountered while drilling. Conventional water-based muds (WBMs) that are used to drill through water sensitive shale formations cause a high degree of wellbore instability. Consequently, oil based muds (OBMs) were adopted to solve the wellbore instability problems due to their superior shale stabilization properties. Unfortunately, high costs, environmental restrictions, cuttings and used mud disposal difficulties, and safety have largely limited the use of Oil base muds. Consequently, WBMs that have the ability to effectively reduce shale instability problems have once again come under the lime light to replace the OBMs. The limited availability of models to adequately describe shale fluid interaction has hindered the growth of inhibitive WBM development. Models based on chemical potential and hydraulic pressure had been developed by Osisanya (1991), and further work by V Osisanya, et al (1996) have indicated the complexity of theoretical analysis of driving forces and mechanisms that govern shale stability in the borehole.

The use of conventional WBMs in drilling shale formations results in the adsorption of water associated with the drilling mud onto the surface of shale (Chenevert 1970). Depending on the shale type, water adsorption may lead to various reactions such as swelling, cuttings dispersion, and increase in pore pressure (Chenevert 1973) creating wellbore instability to varying degrees. Common failures that occur from shale instability using conventional WBMs include sloughing, caving, stuck pipe, bit balling and increased torque and drag. These failures can grow into massive expenses due to lost non-productive time. In general, drilling fluid weight and chemical compositions are the elements that are manipulated in order to control such

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instabilities. However, instabilities in shale may be caused by a complex mechanism of shale drilling fluid interaction ranging from mechanical to chemical reasons(Al-Bazali, 2005). Therefore proper selection of the drilling fluids to be used on a particular well site is an essential phase of any carefully planned drilling operation. When this drilling is expected to encounter shale zones, the selection of the fluid becomes even more important. To maintain a stable borehole through such zones, a carefully designed mud will be required. The design of successful fluids for this type of application depends largely on a knowledge of the physical and mineralogical characteristics of the shale and its behavior when in contact with drilling mud.

Potassium-based muds are used in areas where inhibition is required to limit chemical alteration of shales. Potassium performance is based on cationic exchange of potassium for sodium or calcium ions on smectites and interlayered clays. The potassium ion compared to calcium ion or other inhibitive ions, fits more closely into the clay lattice structure, thereby greatly reducing hydration of clays . Potassium-based muds perform best on shales containing large quantities of smectite or interlayered clays in the total clay fraction. Shallow shales, containing large amounts of montmorillonite, however, still swell in a potassium-based system. In recent years, muds containing potassium chloride and a suitable polymer have been the subject of publications from several areas. Laboratory studies of the effects of several salt solutions on the hardness of cores from water-sensitive sands showed that 2% potassium chloride was a more effective stabilizing agent than was 2% calcium chloride or 10% sodium chloride.

In 1960, while drilling steeply dipping shales in the Cerro Pelado area of Venezuela, noted improved hole stability when mud containing potassium ion replaced the commonly used sodium or calcium ions to inhibit clay swelling. Hole enlargement in the shale section was significantly reduced a result attributed to the inhibitive properties potassium ion and cited in a patent application filed in September 1963.

The objective of this work, therefore, is to evaluate experimentally the degree of inhibition of different concentrations of KCl on Shale contaminated WBM.

II. Materials and Research Methodology

341grams of water was measured and poured into the Hamilton mixing cup. 4.0grams of bentonite was added and prehydrated for 30 minutes under stirring condition. After 30 minutes, 0.2grams of xanthan gum, 0.4grams of Pac-R, 0.6grams Pac-L respectively were added to the mixing cup. These with prehydrated bentonite was stirred for 15 minutes before 0.25grams of Soda ash was added and stirred for another 10 minutes. Then 13.0 grams of barite was finally added and the mixture was stirred further for another 20 minutes for homogeneity before taking the rheological readings and(10 seconds/minutes) gel strength using VG meter.

The mixing procedure was repeated using the grounded sample of shale. Different weights of the shale (1%,2%,4%,7%,10%) respectively by weight of the formulated mud were added. Thereafter, the KCL(0.2%, 0.4%,1.0%, 2.0% and 4.0%) by weight of the formulated mud were added respectively. The rheological readings and(10 seconds/minutes) gel strength values were recorded as well. The plastic viscosity and Yield Point values were evaluated as applicable.

Table 1 : Additives and Functions

S/N	ADDITIVE(S)	FUNCTION(S)
1	Water	Base fluid
2	Soda Ash	Calcium precipitant and pH reducer in cement contaminated mud
3	Bentonite	Viscosity and Filtration control
4	XCD	Viscosity and Filtration control
5	Par R	Fluid loss control and Viscosifier
6	Par L	Fluid loss control and Viscosifier
9	Barite	Weighting agent
10	KCl	Clay inhibitor

III. Results and Discussion

The results of the various tests are recorded in the tables below.

Table 2 : Rheological properties of formulated mud(8.5PPG)

S/N	RPM	DIAL READING
1	Ø600	21(Cp)
2	Ø300	14(Cp)
3	Ø6	2(Cp)
4	Ø3	2(Cp)
5	Plastic Viscosity(Cp)	7(Cp)
6	Yield Point (lb/100Ft^2)	7(Cp)
7	10Sec Gel strength(lb/100Ft^2)	1
8	10Mins Gel strength(lb/100Ft^2)	2

Table 3 : Shale Components

S/N	PARAMETER	RESULT
1	Native moisture content %	13.83
2	Cation Exchange Capacity Meq/100g	2.92

Table 4 : Rheology results for the shale/mud at different concentrations

MIXTURE	600 RPM (Cp)	300 RPM (Cp)	6RPM (Cp)	3RPM (Cp)	10sec gel(Cp)	10ming el(Cp)	PV (Cp)	YP (lb/100ft^2)
Mud+1.0% shale	23	15	2	1	1	1	8	7
Mud+2.0% shale	30	18	2	1	1	2	12	6
Mud+4.0% shale	32	21	5	3	4	7	11	10
Mud+7% shale	35	25	11	10	10	10	10	10
Mud+10% shale	45	24	12	11	11	13	21	3

Table 5 : Rheology results for the shale/mixture at different concentrations with KCl

MIXTURE	600 RPM (Cp)	300 RPM (Cp)	6RPM (Cp)	3RPM (Cp)	10sec gel(Cp)	10ming el(Cp)	PV (Cp)	YP (lb/100ft^2)
Mud+1.0% shale+0.2%kCl	23	17	2	1.5	2	3	6	1
Mud+2.0% shale+0.4% KCl	22	13	2	1	1.5	2	9	4
Mud+4.0% shale+1.0%KCl	20	12	2	1	1	2	8	4
Mud+7% shale+2.0% KCl	18	11	2	1	1	2	7	4
Mud+10% shale+4.0% KCl	16	12	3	2	2	3	4	8

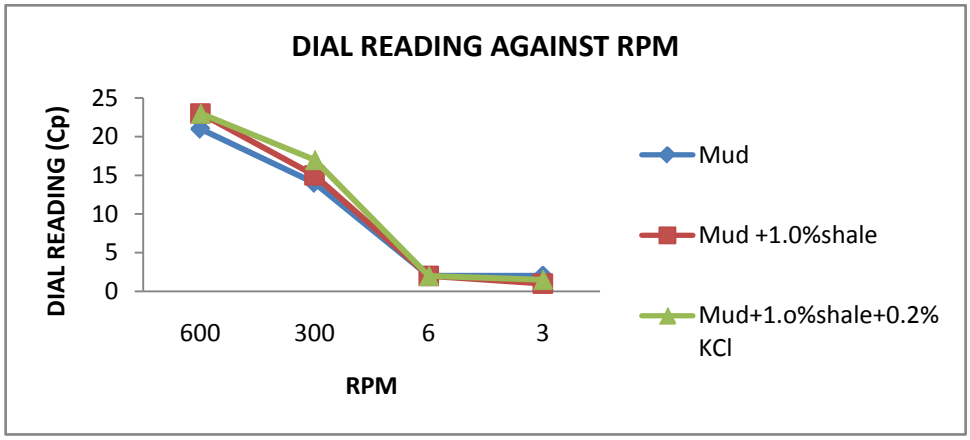

Fig 1 : Dial Reading Against RPM

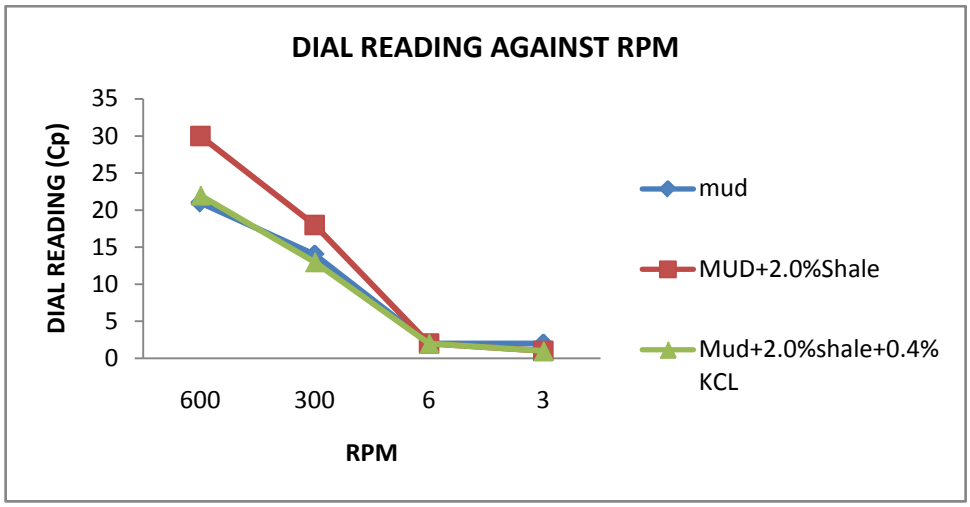

Fig 2 : Dial Reading Against RPM

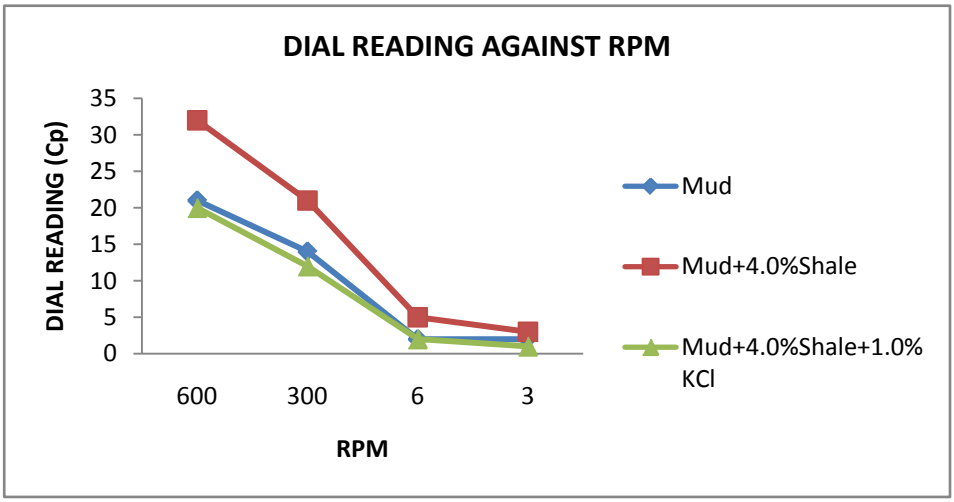

Fig 3 : Dial Reading Against RPM

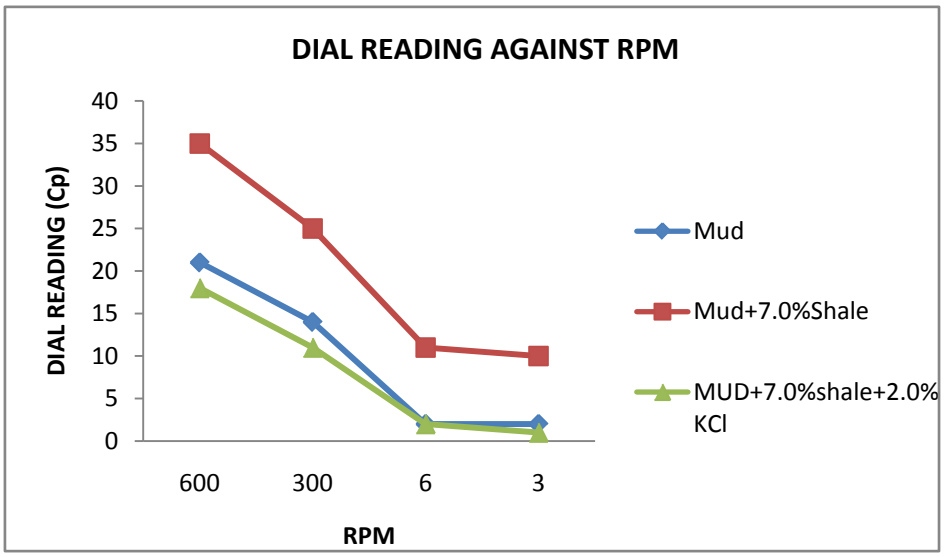

Fig 4 : Dial Reading Against RPM

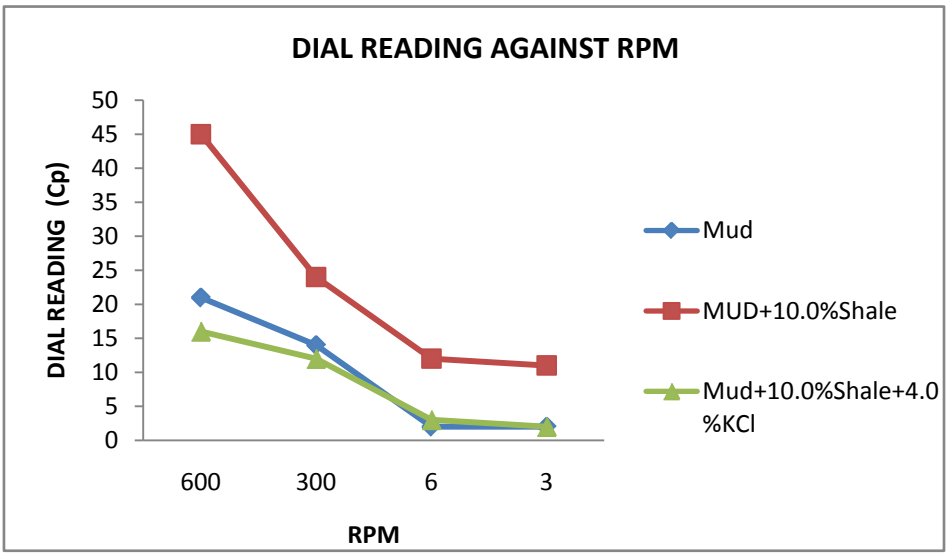

Fig 5 : Dial Reading Against RPM

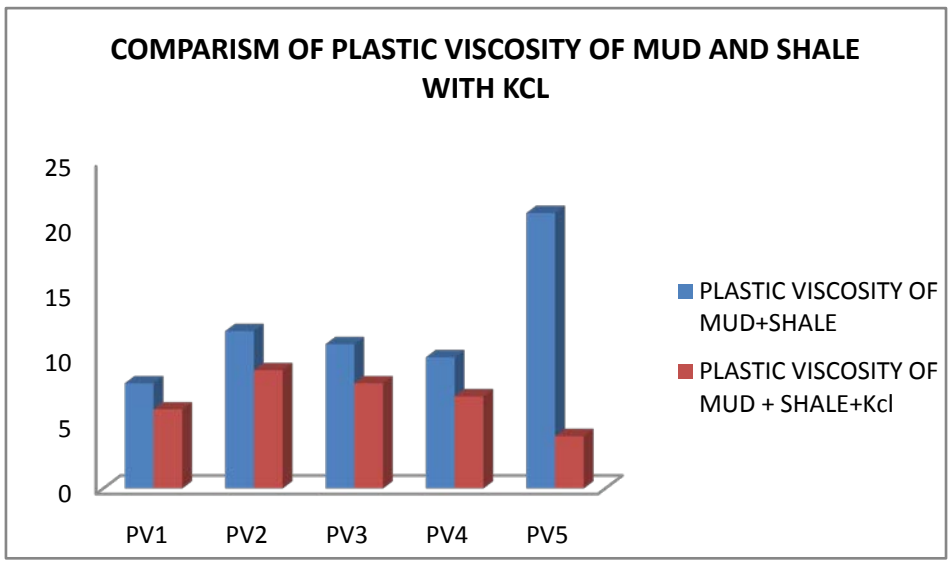

Fig 6 : Coparism of Plastic Viscosity of Mud and Shale With Kcl

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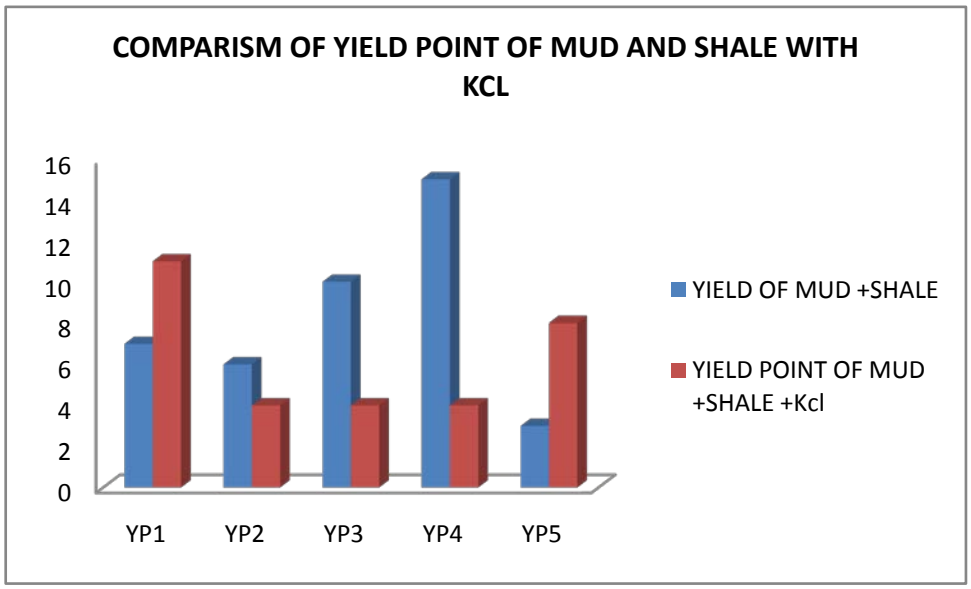

Fig 7 : Coparism of Yield Point of Mud and Shale With Kcl

Table-1 shows the composition of the 8.5PPG mud recipe and various functions of the additives. Results of the formulated mud recipe is reflected on Table-2 while Table -3 details the result for the shale composition, indicating a native moisture content of 13.83% and Cation exchange capacity of 2.92Meg/100g. The 13.83% moisture content indicates high presence of expandable clays with the ability to store moisture easily.

Table-4 gives results with mud contamination with different shale weights. Looking at Table-4 and figures 1-5, with 1.0%,2.0%, 4.0%, 7.0% and 10.0% shale contamination respectively and considering the 600rpm reading, test results indicated that the rheological values increased progressively showing a spike as the shale concentration increased. The increase in rheological values were 9.5%(from 21 to 23 Cp), 42.9%(from 21 to 30 Cp), 52.4%(from 21 to 32 Cp),66.7% (from 21 to 35 Cp) and 114.3%(from 21 to 45 Cp), respectively for the various contaminations as indicated above. This agrees with previous findings on this phenomenon(Joel,2012). The use of conventional WBMs in drilling shale formations results in the adsorption of water associated with the drilling mud onto the surface of shale (Chenevert 1970). However, when KCl was introduced(0.2%, 0.4%,1.0%, 2.0% and 4.0%) by weight of the formulated mud sample respectively, there was progressive reduction in the rheological values with increase in KCl concentration, no increase for 0.2% KCl, (30cP to 22cP for 0.4%KCL), (32cP to 20cP for 1.0%KCl), (35cP to 18cP for 2% KCl) and (45cP to 16Cp for 4%KCL). Test results indicated that the KCl inhibited the swelling tendencies of the shale and the rheological values reduced drastically and considering the 600rpm reading, the percentage reductions were 0%, 36%, 60%, 94% and 181% respectively compared to results without KCL in the mud as indicated above. This agrees with previous studies that potassium chloride is very effective stabilizing agent in shale sensitive formation.

Fig-6 shows the Plastic Viscosity result of the mud with different concentrations of the shale. The test result indicated that as the concentration of shales increased, the plastic viscosity increases, however, there was a noticeable reduction in the plastic viscosity values with introduction of KCl.

Fig-7 shows the yield point results with the different concentrations of shale. The highest shale concentration gave the least yield point value. This is an indication of dispersion and settling tendency of the solid particles in the mixture. Depending on the shale type, water adsorption may lead to various reactions such as swelling, cuttings dispersion, and increase in pore pressure (Chenevert 1973) creating wellbore instability to varying degrees. However, the introduction of KCL resulted to reduction in the yield point values.

References Références Referencias

1. Adamson A.W(1982): "Physical Chemistry of Surfaces", 4th Edition, John Wiley & Sons, pp 521-534.
2. Al-Awad N.J. and Smart B.G.D(1996): "Characterization of Shale-Drilling Fluid Interaction Mechanisms Related to Wellbore Instability", J. King Saud Univ., Vol.8, Eng. Sci. (2), pp 187-215.
3. Ayoub R.F., Tan C.P., Clennell B., Yang J., Tohidi, B(2004): "Wellbore Stability Issues in Shales or Hydrate Bearing Sediments". AAPG Hedberg

Research Conference, Vancouver, September, 2004.
4. Baver L.D(1956).: "Soil Physics", 3rd Edition, John Wiley & Sons, pp 36-37.
5. Borgoyne A.T., Chenevert M.E., Millheim K.K, Young F.S.(1986): "Applied Drilling Engineering", SPE Textbook Series, Vol. 2, pp 53, 76-77.
6. Chenevert M.E. and Pernot V(1998): "Control of Shale Swelling Pressures Using Inhibitive Water Based Muds", SPE 49263 presented at the SPE Annual Technical Conference and Exhibition, New Orleans, September 27-30.
7. Chenevert, M.E. and Osisanya, S.O(1992): "Shale Swelling at Elevated Temperature and Pressure", presented at the 33rd Symposium in Rock Mechanics, Santa Fe, New Mexico, June 8-10.
8. Chenevert M.E. and Osisanya S.O(1989): "Shale/Mud Inhibition Defined with Rig-Site Methods", SPE Drilling Engineering, September, 1989.
9. Clark R.K., Scheurman R.F., Rath H., Van Larr H.G(1976): "Polyacrylamide/Potassium- Chloride Mud for Drilling Water-Sensitive Shales", SPE 5514, Journal of Petroleum Technology, June 7-9, pp 86.
10. David R. Lide, 2004: "Hand Book of Chemistry and Physics: A Ready Reference Book of Chemistry and Physics data", 85th Edition,
11. Darley H.C.H(1969): "A Laboratory Investigation of Borehole Stability", JPT Trans, AIME, July, 1969,PP 883-892,
12. Darley H.C.H and Gray G.R(1991): "Composition and Properties of Drilling and Completion fluids", Fifth Edition, Houston, Texas, Gulf Publishing Company, 1991. Procedure for native moisture content determination
13. Joel, O.F, Durueke, U.J and Nwokoye C.U(2012): Evaluation of Effect of Different Concentrations of Shale on Rheological Properties of Water-based Mud, 36th Annual SPE International Technical Conference and Exhibition, in Lagos-Nigeria, August 6-8,, 2012.

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New Biogas Renewable System for Combined Sofc-Electricity Generation with a Membrane Reactor

By S. Vasileiadis, Z. Ziaka, M. Tsimpa & E. M. Vasileiadou

Hellenic Open University, Patras

Abstract - This paper presents and analyzes a new biogas based catalytic reforming-processing system for the conversion of gaseous hydrocarbons (coming from manure type anaerobic digesters) such as methane into hydrogen and carbon oxide mixtures. The exit synthesis gas (syn-gas) is introduced to power effectively high temperature fuel cells such as SOFC types for combined efficient electricity generation.

Keywords : *Biogas reforming, fuel cell, membrane reactor, catalytic reactor, SOFC, renewable energy.*

GJRE-C Classification : *FOR Code : 090405*

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S. Vasileiadis [α], Z. Ziaka [σ], M. Tsimpa [ρ] & E. M. Vasileiadou [ω]

Abstract - This paper presents and analyzes a new biogas based catalytic reforming-processing system for the conversion of gaseous hydrocarbons (coming from manure type anaerobic digesters) such as methane into hydrogen and carbon oxide mixtures. The exit synthesis gas (syn-gas) is introduced to power effectively high temperature fuel cells such as SOFC types for combined efficient electricity generation.

Moreover, this research targets on the description and design aspects of permreactors (permeable reformers) carrying the same type of renewable-biogas reforming reactions. The goals of such a research include turnkey system and process development for the biogas based power generation and fuel cell industries. The proper utilization of biogas and waste type resources (coming from manure type anaerobic digesters) for green-type/renewable power generation with increased processing capacity and efficiency via SOFCs is introduced as well. Pollution reduction is under additional design benefit in the described catalytic processors-fuel cell systems, at the same time. Three different reactor configurations are examined and compared. The use of a membrane reformer and of a catalytic membrane reformer offer better hydrogen and syngas yields and methane conversions than the corresponding non-membrane plug flow reactor.

Keywords : biogas reforming, fuel cell, membrane reactor, catalytic reactor, SOFC, renewable energy.

I. Introduction

In our earlier IASTED and ACS presentations (PGRES '02, Marina Del Ray, CA; Modeling and Simulation, '03, Palm Springs, CA; ACS-Fuel Chemistry '02, Boston, MA) we discussed about preliminary findings and results of catalytic processors for the steam reforming of methane, natural gas, and biogas, for use in fuel cell systems such as SOFC types [1].

The recent communication continues this research introducing the so-called "Biogas power" and "Bio-Energy" systems. The use of biogas mixtures (manure based generated feedstocks) as sources for electricity and heat generation using fuel cells of the SOFC type are studied here. Use of manure based gases rich in methane coming from anaerobic digesters, for the production of intermediate synthesis gas is an attractive route in "green power" and "biogas/manure energy" based systems [2]. There is a recent emphasis on the development and commercialization of such SOFC systems for electricity and heat generation applications. Such installations begin to exist currently mainly in US, Europe, Japan, China and other developing countries. Fig.1 below, shows the itemized distribution of biogas energy-applications which is coming from various renewable sources [3].

Fig.1 shows the products that are coming from the biomass treatment process, especially those coming from the anaerobic digestion. In our case however the feedstock is animal wastes and not agricultural or forest biomass.

Such biomass-energy systems require the development and use of an effective catalytic reformer utilizing active metals such as Ni, Rh, Cr, or bimetallic combinations of those. Earth metal enrichment in the catalyst such as with Ca, Mg, La and K promotes the catalyst stability on stream and minimizes deactivation from carbon deposition, especially in the reactor inlet [1,2,4,5].

The reformer used can be a fixed bed catalysis-reactor or a permreactor using membrane type materials as reactor walls. Use of a permreactor creates a two outlet reaction system which carries the synthesis gas product at different compositions. The permeate stream is richer in hydrogen and less rich in carbon oxides, by the use of hydrogen selective membranes such as microporous inorganics (e.g., alumina, titania based) or metal alloys (Pd/Ag, Pd/Cu). One or both of the outlet gas streams can be used as feed in the accompanied fuel cell/SOFC. Use of the permreactor increases the conversion of the reactant biogases in the reactor due to the separation of products. This increased shift in conversion yields the required quantity of synthesis gas product for the fuel cell at a lower operation temperature than the counterpart fixed bed (impermeable) reactor [2]. Process operation at a lower temperature is beneficial for increasing the reactor and catalyst life time and for reducing the endothermic heating load (Btu/hr) of the endothermic reformer. Below, we give design emphasis in both reformer configurations for the generation and delivery of hydrogen rich synthesis gas into the accompanied solid oxide fuel cell.

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The traditional process utilizes directly the biogas via a turbine or an engine for heat and electricity generation without the use of a reformer. However, the process is of low efficiency with a high waste heat rate.

II. Fuel Cell Analysis

The process of reforming methane or higher hydrocarbons with steam is a key catalysis and reaction route for producing high quality hydrogen or synthesis gas for further use, in an economical way [1,2,4,5]. Synthesis gas usually contains hydrogen mixed with carbon monoxide and possibly carbon dioxide as well. The reforming processes taking place are endothermic and use similar catalysis metals as those described above.

Use of biogas based feedstocks as the reactant gases constitute for a methane (CH_4) rich feed in the reformer which is converted with steam into a H_2 and CO rich mixture. The exit hydrogen-rich gas is used as direct fuel in the anode of the solid oxide fuel cell. The reactions of methane steam reforming and water gas shift take place in the reformer by adding steam in the feedstock as the oxidant [2,4,5].

$$CH_4 + H_2O \leftrightarrow CO + 3H_2 \quad (\Delta H^o_{298} = +206.1 \text{ kJ/mol}) \tag{1}$$

(methane - steam reforming reaction)

$$CO + H_2O \leftrightarrow CO_2 + H_2 \quad (\Delta H^o_{298} = -41.15 \text{ kJ/mol}) \tag{2}$$

(water gas shift reaction)

Here we assume that the biogas has been purified before entering into the reformer from the various impurities (e.g., halogens) to avoid among others the deactivation of the catalyst. Further, the contained carbon dioxide and any hydrogen sulfide gases can be separated before the reformer, so that only pure methane is reformed catalytically [2,6]. However, some CO_2 can be flown within the reactor and reformed catalytically together with methane [2].

The catalyst used in the process was in the form of particles of 0.92mm average diameter. The catalyst was a 15% NiO on alumina enriched with calcium and magnesium to withstand deactivation from carbon deposition. 8.03gr of catalyst was loaded in the reformer.

The interconnected solid oxide fuel cell (SOFC) produces electricity by the electrochemical oxidation of both hydrogen and carbon monoxide gases, following a dual electrochemical reaction mechanism [2]. Part of the hot gas exiting from the fuel cell can be diverted in the shellside of the membrane reactor in a closed loop, to provide the necessary endothermic heat for running the reformer.

In the SOFC anode:

$$H_2 + O^{2-} \rightarrow H_2O + 2e^-$$

$$CO + O^{2-} \rightarrow CO_2 + 2e^-$$

In the SOFC cathode:

$$O_2 + 4e^- \rightarrow 2O^{2-}$$

With the overall reaction to be:

$$H_2 + CO + O_2 \rightarrow CO_2 + H_2O \tag{3}$$

Mathematical modeling of the CH_4-H_2O reformer for a steady state fixed-bed catalytic reactor includes the species reaction terms in the mass balance equations. Moreover the thermal and momentum balances are also written for a non-isothermal reformer with pressure drop along its catalyst bed [2]. A detailed analysis of the model, its parameters and their variation is given in earlier communications [2]. The system of these equations is integrated numerically as an initial value problem to provide the reactant conversions, product yields, reactor temperature and pressure along the axial length and to obtain the axial profiles of these variables and their values at the reactor exit.

By employing an inorganic permreactor as the main catalytic processing unit to convert manure biogas feedstocks into fuel cell gas, the above design equations are modified accordingly to include the permeation effects of the different gases via the membrane. In our experimental reaction studies we utilized mesoporous aluminum oxide membranes having a thin permselective layer (3-5μm thickness, 50% porosity) with 40-50Å pore diameter [1,2]. The membranes are multilayer structures having at the end a support layer. The separation of the gases through the membrane follows primarily the Knudsen diffusion. In the case of a permreactor the corresponding mass, temperature, and pressure variation equations are written as well for the gas which permeates via the membrane wall material and flows in the permeate side (S) of the membrane reactor. The detailed model for the permreactor has been described in our earlier communications [2].

By using the above equations within the modeling procedure a detailed reactor analysis is obtained for the two different reformer configurations. Solution of the equations is obtained numerically by using an initial value integration technique for ordinary differential equations with variable stepsize to ensure higher accuracy (implicit Adams-Moulton method) [2].

In our previous communications we have described and analyzed the reaction, separation (i.e., permeation), and process (conversion, yield) characteristics of permreactors (membrane based catalytic reactors) and related processes for methane-steam reforming, water gas shift, and methane-carbon

dioxide reforming reactions including catalysis and membrane materials characteristics [2]. These effective and versatile catalytic systems were applied for pure hydrogen (H_2), H_2 and CO_2, and H_2 and CO (syn-gas) generation to be used as fuel gas for power generation or as synthesis gas for production of specialty chemicals (such as methanol and higher hydrocarbons) [1,2].

The interconnected or integrated solid oxide fuel cell is fed directly by the fuel gas generated by the described reformers. The focus of our studies includes solutions in a number of problems associated with the installation, operation, and mass, energy conservation of the entire fuel cell and membrane-processing unit. The economic feasibility of the overall fuel cell installation is correlated with high efficiency (e.g., 50%-75% for advanced units) and high current density output (A/cm^2), increased system reliability for continuous dispersed power generation, and reduced plant installation, operation and maintenance cost. These targets combined with virtual elimination of pollution by use of fuel cells in stationary (e.g., central and remote power stations) and mobile/transportation (e.g., automobile) sources make this technology highly applicable and attractive. Clean fuel cell power minimizes NOx, CO, and hydrocarbon species in the emissions [2].

III. Results and Discussion

The apparatus used in the experiments consists of mass flow controllers, a bubbler to generate steam for the reaction, the reactor housing wherein the plug flow reactor or the membrane reactor was placed. The apparatus with its details is shown in Fig 2. The reactor is equipped with thermocouples to read the temperature and with pressure transducers to read the pressure. At the exit of the reactor the apparatus consists of steam traps and a gas chromatograph to analyze the exit stream. The gas chromatograph operates in the TCD mode and is equipped with a porapack Q column for the gas analysis.

The idea of biogases utilization, coming from manure-type anaerobic digesters, within the reformer, constitutes an innovative approach in previous attempts for direct use of those feedstocks for power generation [6]. There are important renewable resources of biogas feedstocks today generated from the large herds of farm animals grown in local and remote farms.

The gas that exits from the proper treatment of manure in anaerobic digesters is rich in methane and carbon dioxide, and constitutes the proper mixture for direct conversion into the described reformer/SOFC system. As the flowrate of the manure biogases increases (for larger sites and treatment systems) a larger capacity reformer and fuel cell are required to handle the conversion; consecutively, the final SOFC power output (kW/cm^2) increases as well.

The table 1 shows the percentage of income from the direct utilization of biogases coming from agricultural and farm animal waste sources. It shows the different energy utilization of used biogas in terms of percentage [3].

Fig.1 is a useful flowchart of the biomass conversion process. It includes the anaerobic digestion process which yields methane and synthesis gas products.

The schematic of the experimental apparatus wherein the conversion to synthesis gas is taking place is shown in details in Fig.2.

The performance of two types of reformers for the specific reactions is described. Hence, Fig.3 shows the total hydrogen yield produced from these reactions within the reformer and specifically at the reformer exit as function of the reaction temperature. We report results from a membrane type reformer and from a conventional (non-membrane) plug flow type reformer. The membrane reformer exceeds the non-membrane reformer in the total hydrogen yield and this is also shown by the accompanied modeling results which simulate well the experimental membrane reformer data. Moreover, the plug flow type reformer produces results that are very close to the calculated equilibrium hydrogen yields which are calculated at the tubeside (T) reaction conditions. Hydrogen produced under these conditions is directed in the fuel cell anode to drive the electrochemical reactions discussed above. The feed composition in the tubeside of the membrane reformer was maintained at CH_4: H_2O: Ar: H_2 = 1: 7: 1: 0.75 . Ar gas was added initially in the feed as a diluent to examine the effect of diluting the methane/biogas feed. The space time of the reactor tubeside was maintained at 54.0 $gr_{cat}.hr/gmole_{CH4}$. The reaction temperature range examined in the two reactors was varied from 450-590°C. The pressure in the tubeside of the reformers where the catalyst lies was maintained at about 2-3 psig (1.17atm) during the course of the experiments.

Methane conversion data at various reactor space times are included as well. This data is indicative of the performance of the catalytic methane steam reforming reaction within the reformers. The reaction conditions remained the same as with the above plot (hydrogen yield data). Thus, Fig.4 below, shows methane conversion versus space time data for the production of H_2 and CO syngas (fuel gas). The operation took place at a constant temperature of 550°C. The data is referred to two types of reformers and it is accompanied by simulation fittings by the numerical models developed and described above. It is interesting to notice that the membrane reactor data exceeds both the plug flow reactor and the equilibrium conversion data. The membrane reactor therefore produces more hydrogen and syngas for the joint fuel cell system (SOFC) at various methane inlet flowrates.

The beneficial increase in CO_2 yield with the use of the membrane reformer is shown in Fig.5 below, in comparison with the other data. The CO_2 yield is

indicative of the extent of the water gas shift reaction (reaction (2)). The CO_2 yield also corresponds to the CO conversion according to reaction (2). As one can observe, there is a good agreement by the modeling results (simulation lines) to the experimental CO_2 yield data. The reaction conditions are the same with those described above. The above plots (Figs. 3, 4, 5) are shown the type of syngas (in terms of composition) which is entering into the SOFC system for electricity generation according to reactions (3), [1,2].

The included data shows that fuel gas rich in H_2 and CO compounds can be produced from the described reformers and especially from the membrane reformer for the continuous operation and electricity generation of the SOFC. Another related plot is shown in Fig.6. It shows the generated power by the SOFC for various feed ratios and reforming conditions (i.e., reaction temperature, inlet feed composition). The plot assumes a 60% fuel cell efficiency at equilibrium fuel gas composition according to reactions (1) and (2). As the steam to methane ratio is increased in the inlet the power output is increased as well. Higher power outputs (kW) can be achieved usually between 600-800·C.

Finally, Table 2 below presents a summary of specifications from a medium biogas processing plant (farm-animal wastes plant) for energy cogeneration. The table shows details on the energetic distribution outcome of the entire plant (e.g., 60% electricity generation efficiency for the SOFC). The data refers to 4,420 swines as the total number of farm animals. This table is included for comparison purposes, in order to provide the potential of the newly described biogas to SOFC unit. It is important to say that the electricity generated by the SOFC (assuming a 60% efficiency) can cover the needs of the farm and any excess electricity can be sold in the nearby electrical network. Moreover, the useful heat from the SOFC can cover the heating needs of the farm (e.g., via a boiler) and those of the endothermic reformer.

Two more figures are also shown below for the socalled PBCMR configuration. In these plots the membrane was also rendered catalytic by the incipient wetness method. A solution of $NiNO_3$ was used to impregnate the ceramic membrane tube. The data shown in Figs. 7 and 8 was taken under these conditions. It is important that the PBCMR (packed bed catalytic membrane reactor) exceeds substantially in both conversion and yield the CPFR (catalytic plug flow reactor) data. The PBCMR data are also higher than the equilibrium calculated conversions and yields. These facts are attributed to the use of the catalytically impregnated membrane as the reactor of the system. The feed composition in the tubeside of the membrane reformer was maintained at CH_4: H_2O: H_2 = 1: 4: 0.20. The space time of the reactor tubeside was maintained at about 50.0 gr_{cat}.hr/$gmole_{CH4}$. The reaction temperature range examined in the two reactors was varied from 475-550·C. The pressure in the tubeside of the reformers where the catalyst lies was maintained at about 10 psig (1.68atm) during the course of the experiments. The developed computational model for the PBCMR shows a pretty good agreement with the experimental membrane reactor data. Thus, the catalytic impregnation of the membrane is an additional advantage of the described system by offering higher hydrogen yields and methane conversions.

IV. Conclusions

In this paper, it is shown that the operation of high temperature SOFCs/fuel cells can be coupled with reforming reactors of biogases. The SOFCs can operate in series or integrated with a catalytic reformer or a membrane reformer which convert biogas into fuel gas at various operating conditions. Biogases are rich in CH_4 and are converted catalytically into a H_2 and CO mixture suitable for the continuous operation of the SOFC unit. Our reactors have been also simulated by computational models which account for the reaction and hydrogen separation in the permeable reformers. Various operating conditions in the permeable reformers have been tested by these models. The membrane based permreactor has shown to offer better hydrogen yields and better methane conversions than the counterpart fixed bed based reactor. Among the membrane reactors examined the PBCMR found to perform superior than the simple (non-catalytic) membrane reactor. This happens most probably due to the catalytic membrane contribution as well.

Essential distributed power generation within a wider power grid can be accomplished through this design, which can cover the local needs of municipal and remote areas. Fuel cell power relates to the reformer conversion and the efficient utilization of the syngas by the fuel cell. In addition, the waste heat from the conversion of syngas to electricity can be decreased with the fuel cell operation, especially with this of high efficiency SOFCs. Moreover, fuel cell/SOFC continuous operation and power generation from biogases contribute to the pollution minimization, higher power density and efficiency in comparison with conventional power operations. With the use of clean SOFC power, we can also minimize NOx, CO, and hydrocarbon species from the emissions of such stationary biogas power construction.

References Références Referencias

1. Vasileiadis S., and Z. Ziaka, (2002), "Catalytic reactor configurations for hydrogen generation and inline fuel cell operation", in *Proc.: Advances in Hydrogen Energy*, *American Chemical Society, Fuel Chemistry Division,* Vol.47, No.2, Boston, MA, Aug.18-24.

2. Ziaka Z.D., and S.P.Vasileiadis, (2009), "*Membrane reactors for fuel cells and environmental energy systems*", Book, Xlibris Publishing Co., Indianapolis, USA.
3. Sfetsioris K., (2010), "Energy generation and management", Available at: www.chemeng.ntua.gr/courses/bpy/files/sfetsioris.pdf
4. Xu J., and G.F. Froment, (1989), *AIChE Journal*, vol. 35,1, 88-96.
5. Van Hook J.P., (1980), *Catal. Rev. Sci. Eng.,* vol. 21,1,1.
6. Rautenbach R., and K. Welsch, (1994), J. Membrane Science, vol. 87, 107.
7. Ziaka Z., and S. Vasileiadis, (2000), USPatent #6,090,312.
8. Vasileiadis S., and Z. Ziaka, paper No.13, "Efficient catalytic reactors-processors for fuel cells and synthesis applications", in *Proc. 17th International Symposium on Chemical Reaction Engineering,* Hong Kong, China, Aug. 25-28, 2002.
9. Ziaka Z., and S. Vasileiadis, "Catalytic reforming - shift processors for hydrogen generation and continuous fuel cell operation", in *Proc. IASTED-Power and Energy Systems*, Marina Del Ray, CA, pp.360 365, May 2002.
10. Vasileiadis S., and Z. Ziaka, "Methane and methanol steam reforming in a membrane reactor for efficient hydrogen production and continuous fuel cell operation", 1st International Symposium on Intermetallic Compounds in Methanol Steam Reforming, Max Plank Institute, Berlin, Germany, Sept. 2011.
11. Vasileiadou E. M., "Biogas processes and applications", Independent study, Thessaloniki, 2011.

Table 1 : Percentage of income from the direct utilization of biogas coming from agricultural sources and animal wastes [3].

Cooling	19%
Electricity	43%
Heat	36%
Electric Power availability	2%

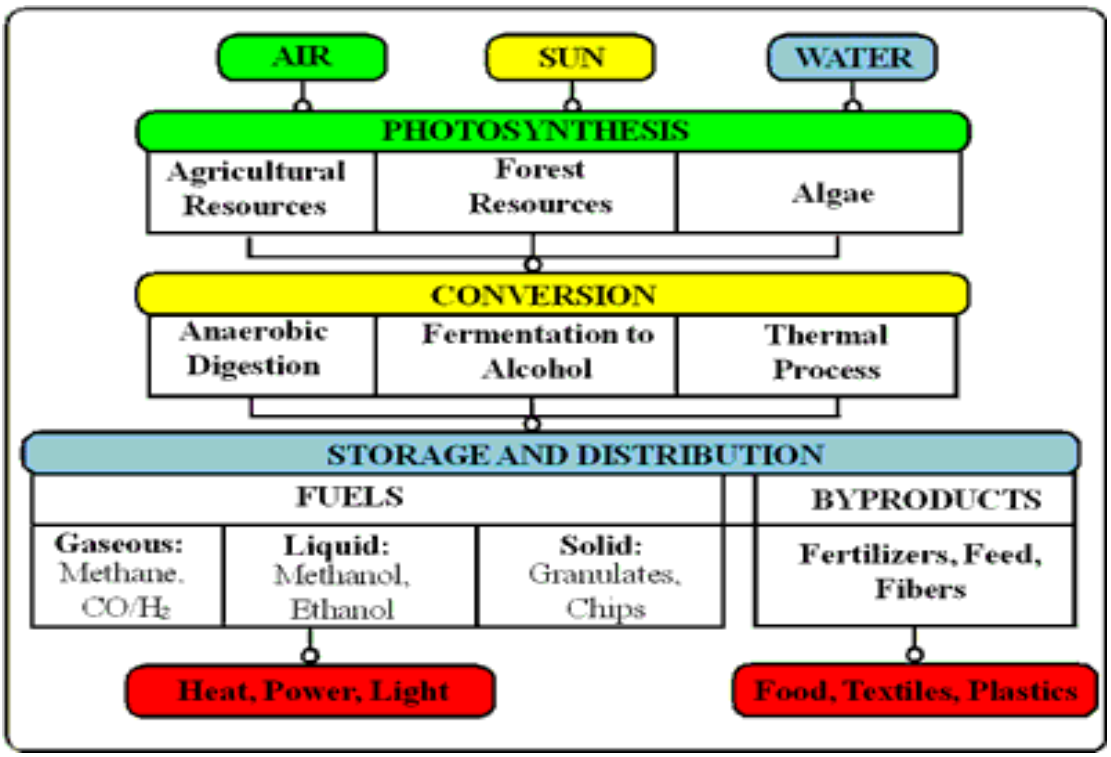

Fig.1 : Flowchart of biomass processes including the anaerobic digestion process for production of methane and synthesis gas.

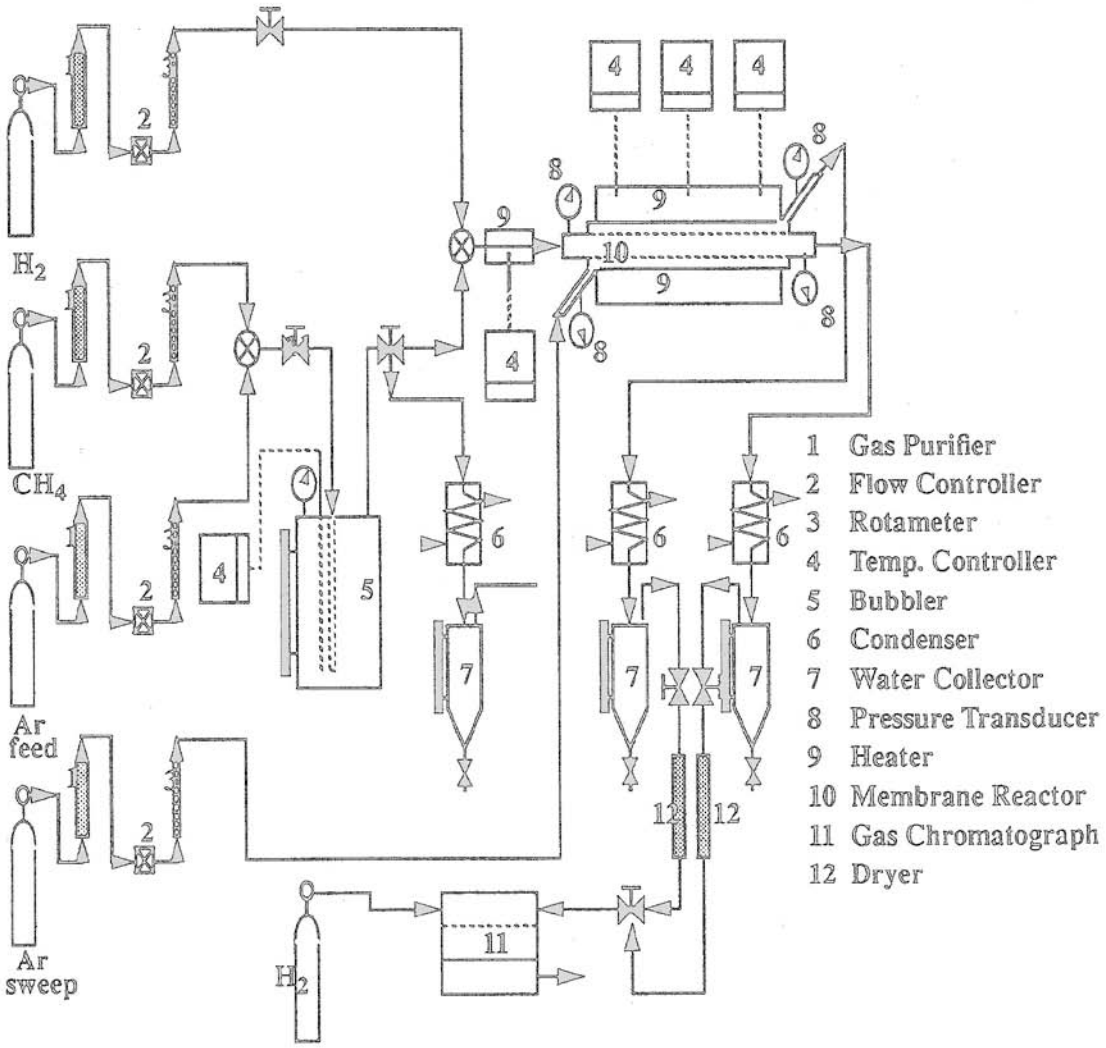

Fig. 2 : Schematic of the experimental apparatus for methane steam reforming.

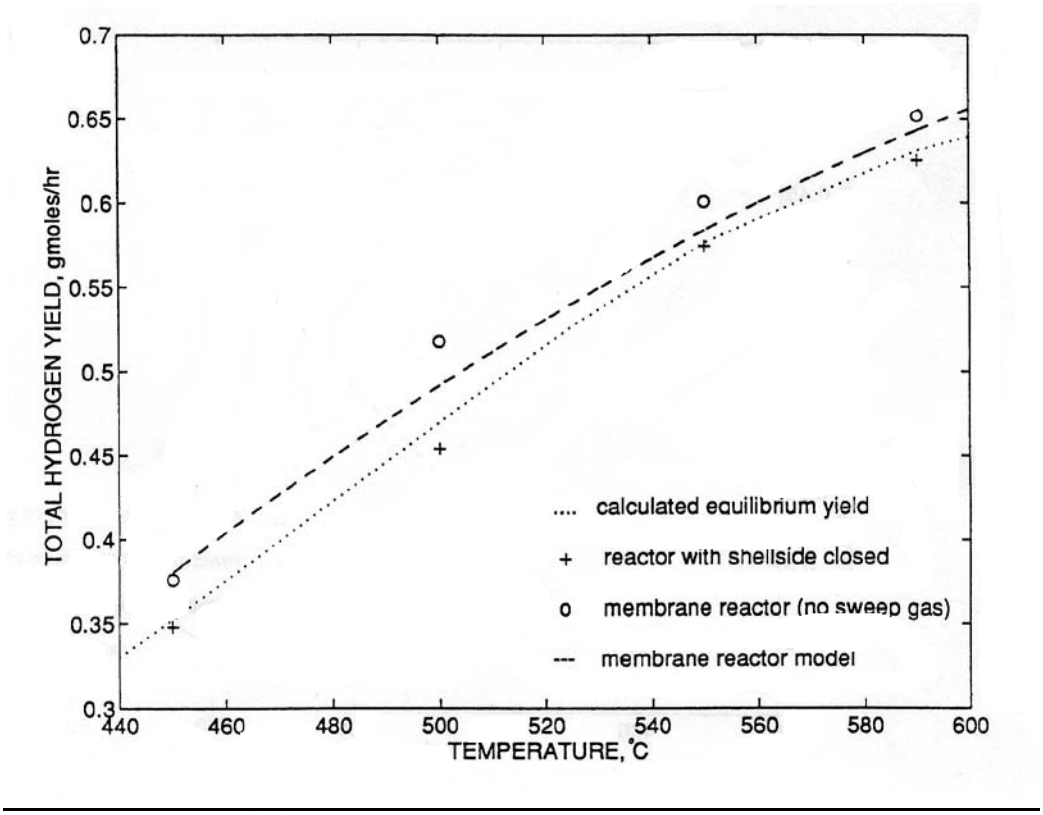

Fig. 3 : Experimental amd modeling results of biogas-steam reformers for syngas production and SOFC continuous operation.

Total hydrogen yield data; (P_{To}=1.17 atm, space time = 54.0 g_{cat}.hr/gmole $_{CH4}$)

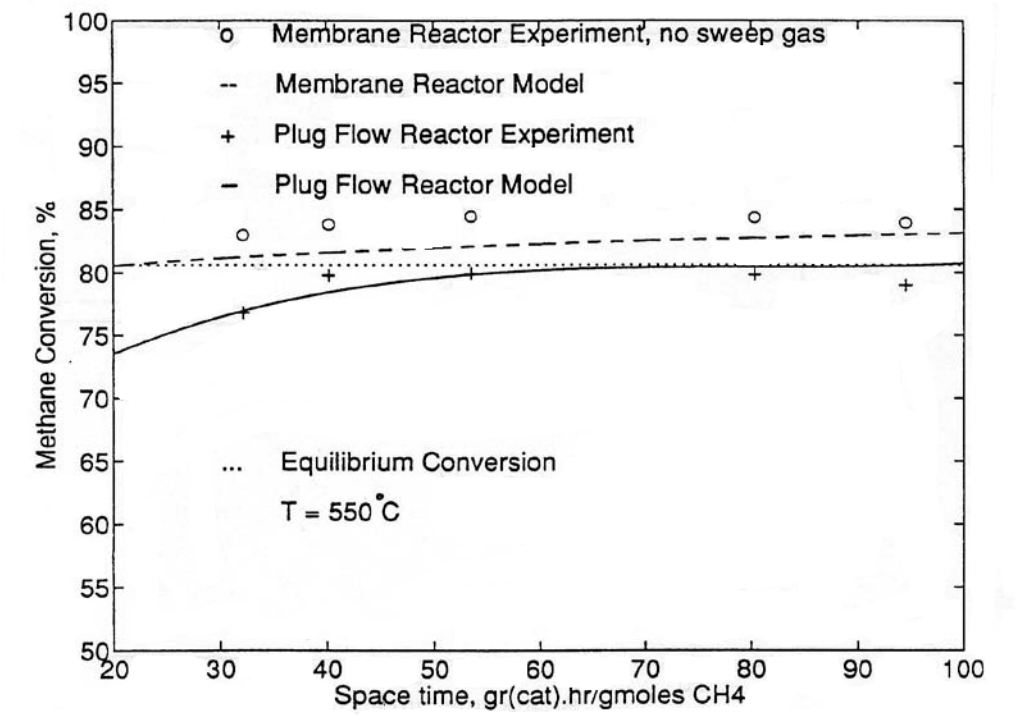

Fig.4 : Experimental amd modeling results of biogas-steam reformers for syngas production and SOFC continuous operation.

Total methane conversion data; (P_{To}=1.17 atm, space time = 54.0 g_{cat}.hr/gmole $_{CH4}$

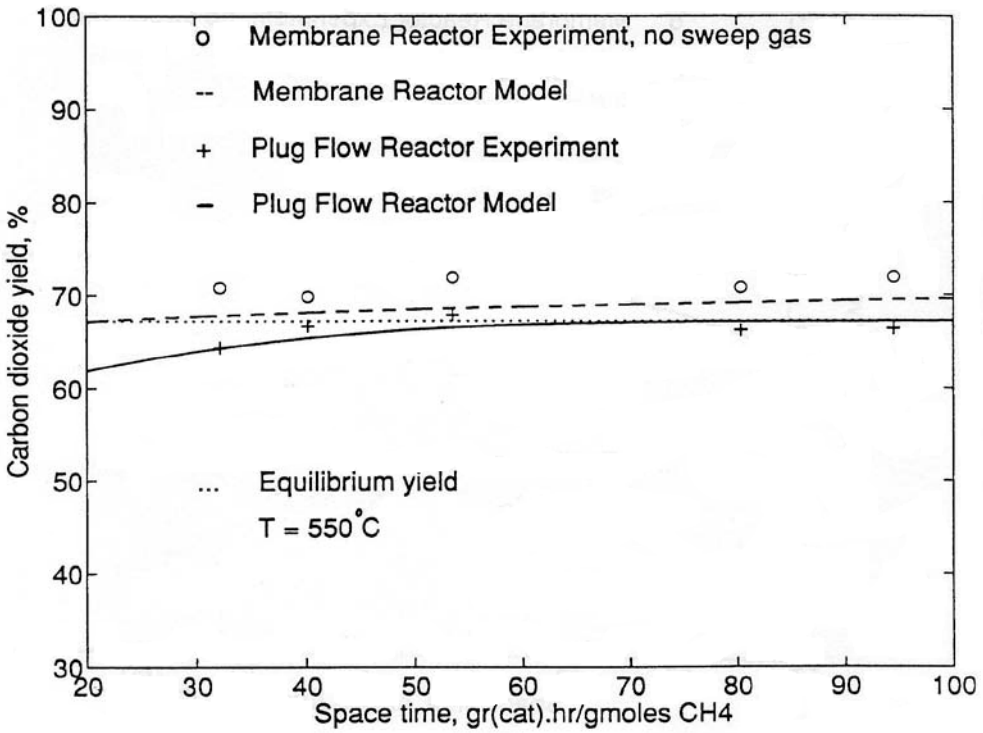

Fig.5 : Experimental amd modeling results of biogas-steam reformers for syngas production and SOFC continuous operation.

Total CO conversion data (CO_2 yield); (P_{To}=1.17 atm, space time = 54.0 g_{cat}.hr/gmole $_{CH4}$

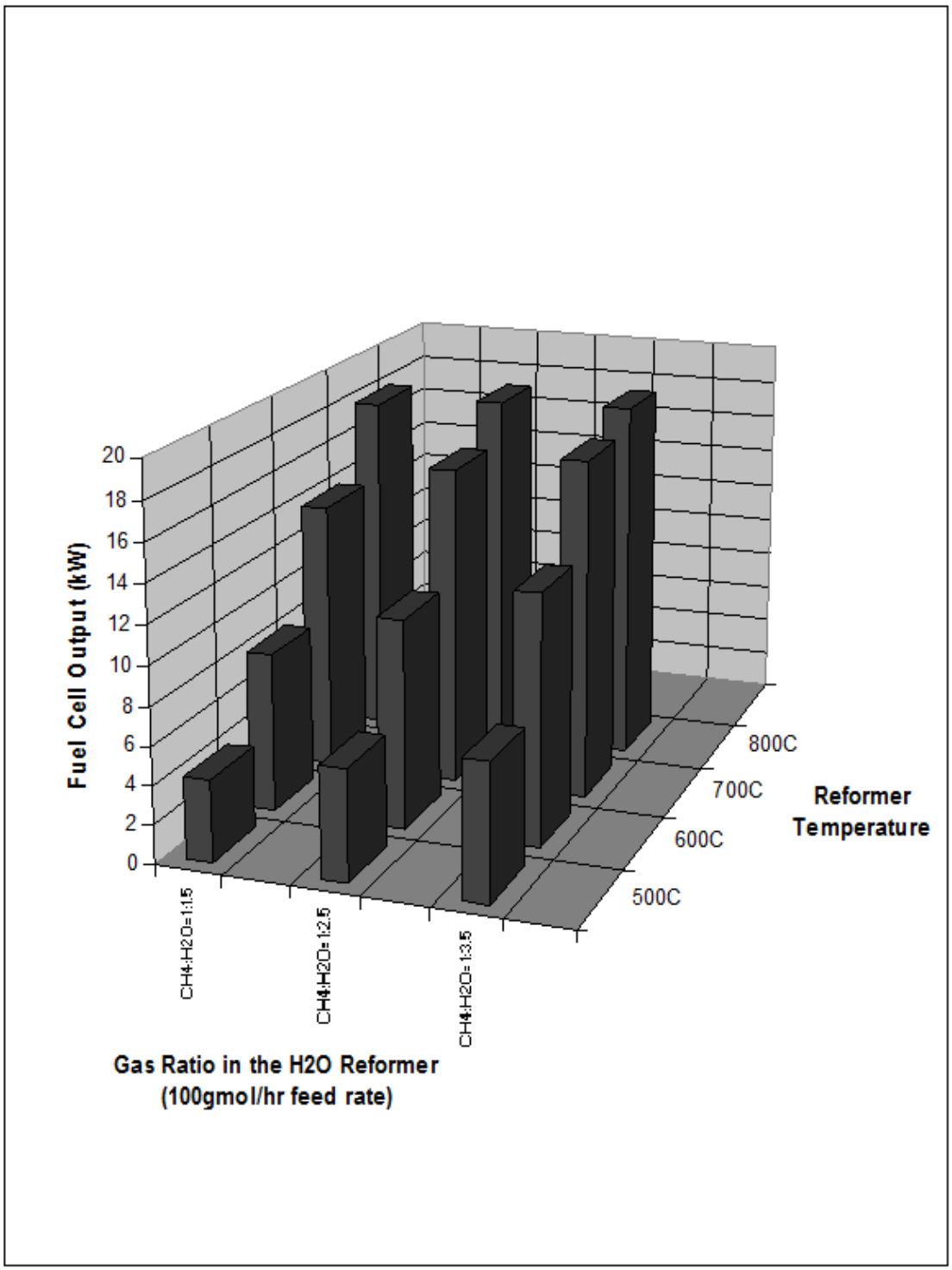

Fig. 6 : SOFC power (kW) versus catalytic reforming conditions (inlet flowrate and temperature); 60% SOFC efficiency at equilibrium fuel gas composition.

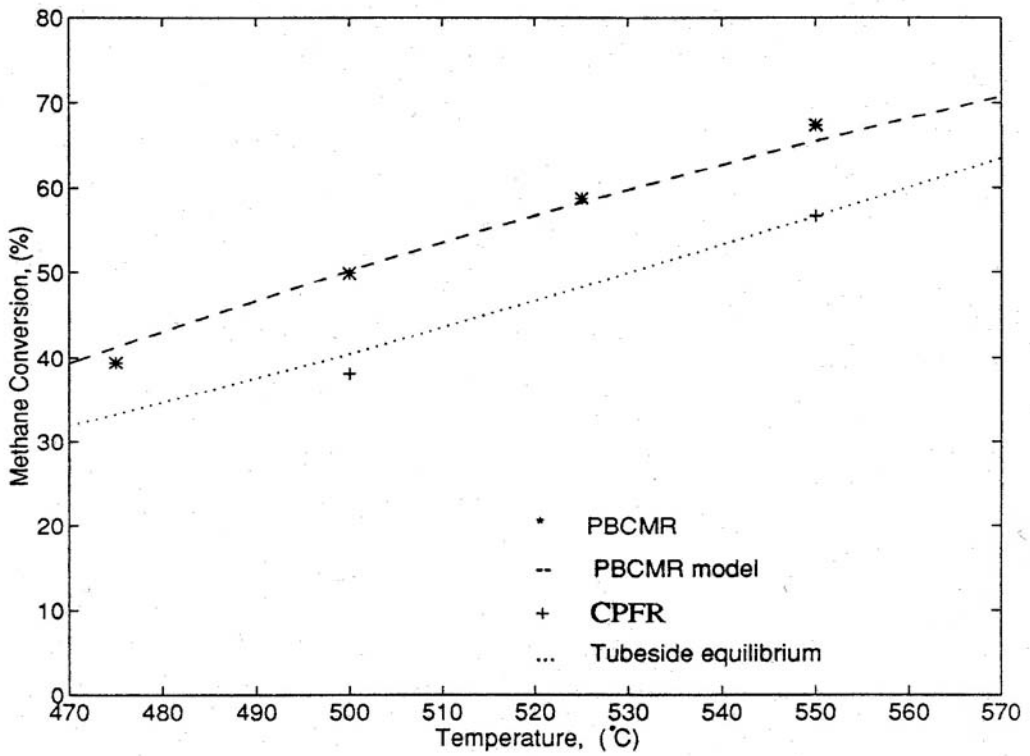

Fig. 7 : Experimental and modeling results of biogas-steam reformers for syngas production and SOFC continuous operation.

Total methane conversion data in the PBCMR configuration; (P_{To}=1.68 atm, space time = 50.0 g_{cat}.hr/gmole $_{CH4}$

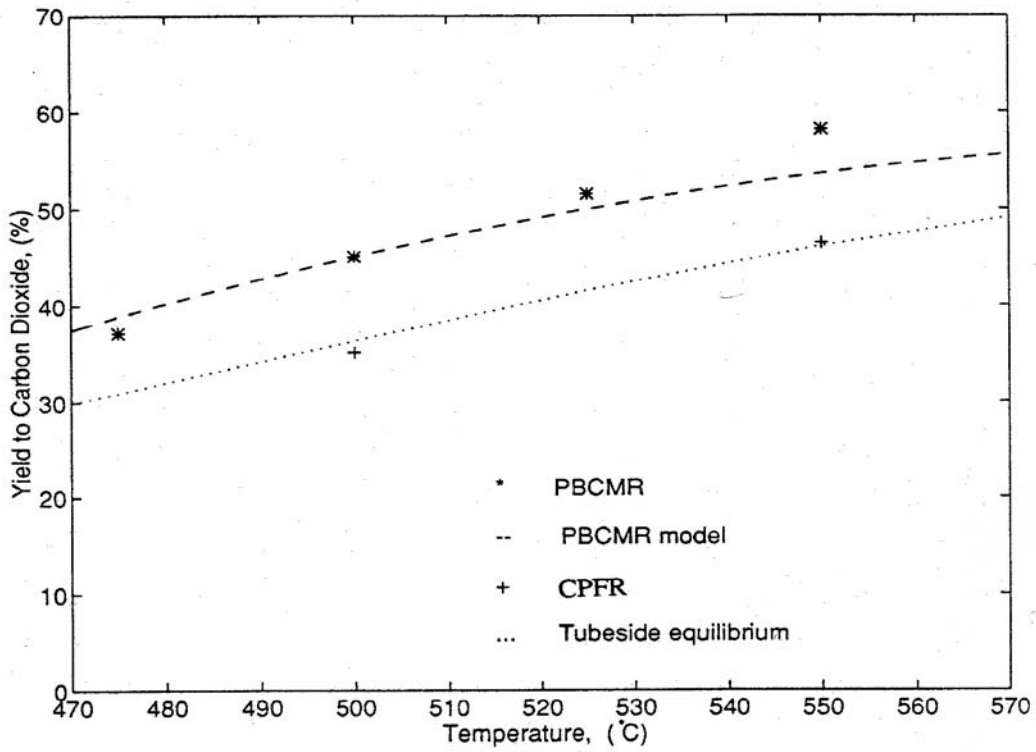

Fig. 8 : Experimental and modeling results of biogas-steam reformers for syngas production and SOFC continuous operation.

Total CO_2 yield data in the PBCMR configuration; (P_{To}=1.68 atm, space time = 50.0 g_{cat}.hr/gmole $_{CH4}$

Table 2 : Specifications of a representative medium size biogas steam reforming-SOFC system, for electricity and heat cogeneration .

Biogas production volume: (From the Manure Anaerobic Digester)	7,200 m^3/day
Total number of farm animals : (swines)	4,420
Methane production volume/about:	5,040 m^3 CH_4/day
Total energy generation:	71,410 kWh/day
Electricity generation/SOFC (60%) :	42,846 kWh/day
Heat generation (30%) :	21,423 kWh/day
Waste heat (about 10%):	7,141 kWh/day
Annual Electricity Generation:	15,400 MWh/year
Sale price per MWh (to DEH, Greek Electricity Authority),	73 Euro/MWh Income about: 1,124,200 Euro/year
Annual Heat generation:	7,712 MWh/year

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Correlation of Suspended Solids (Ss) and Permanganate Value (Pv) of Domestic Sewage From an Estate In Warri, Nigeria

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Abstract - Samples of domestic sewage obtained from a sewage treatment plant located in Warri, Nigeria were analysed for two pollution characteristics such as suspended solids (SS) and permanganate value (PV). Values obtained from the analysis were used to assess the possible relationship between the two pollution characteristics using correlation and regression analysis. Mean values of the suspended solids (SS) ranged between 200.0mg/l and 380.0mg/l while mean values of the permanganate values ranged between 162.2mg/l and 286.0mg/l. The correlation coefficient, r was 0.9577. The analysis indicates that real, strong and significant linear relationship exists between suspended solids and permanganate value in the domestic sewage.

Keywords : *Correlation, SS, PV, Domestic sewage, pollution, pollution characteristics.*

GJRE-C Classification : *FOR Code: 090499*

Strictly as per the compliance and regulations of:

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I. Introduction

Over the years man has experienced serious environmental impact of wastewater discharged from various sources. Wastewater from residential area is referred to as domestic sewage. This includes sanitary sewage (excreted waste from humans), kitchen, bath, laundry and floor drain wastes [1].Domestic sewage together with the sewage from commercial and industrial establishments are referred to as municipal sewage [2].

The common constituents of domestic sewage include organic and inorganic matter, solids (both suspended and dissolved) and microorganisms. These substances are present as contaminants and the concentration is normally expressed in milligrams of contaminants per litre of the mixture [3].

Sewage typically contains bacteria, viruses and other parasites which are pathogenic. Such pathogenic organisms are disease causing which grow and multiply fast in the intestinal tracts of their hosts e.g. man animals [4]. The faeces of such infested host or carriers can get into a water supply or swimming area easily by direct discharge of raw sewage into the receiving water (river, stream, lake, ocean etc). Such direct discharge causes sewage pollution and serious epidemics. Examples of such diseases transmitted due to direct sewage disposal are water borne diseases (cholera, dysentery, diarheoa typhoid hepatitis etc) and water contact diseases (e.g. schistosomiasis, leptospirosis, tularemia etc) [5].

Discharge of sewage into a water body reduces the water quality due to pollution by the wastes in the sewage. The greater the pollution load, the poorer the quality of water [6].

All matter except the water contained in liquid is classified as solid matter. Dissolved solids can be differentiated from suspended solids by filtration [7]. Solids in water are undesirable because they degrade the quality of water. When the solid content of any water is high, additional mechanical and chemical treatment is required and cleaning process becomes more expensive [8].

High levels of solids in water also increase the density of water and reduce the solubility of gases like oxygen. Proteins and carbohydrates are biodegradable contaminants which constitute 90% of the organic matter in domestic sewage. The sources of these biodegradable contaminants include excreta and urine from humans; food wastes from sinks; soil dirt from bathing, washing and laundering; plus various soaps, detergents and other cleansing products. Suspended solids in untreated sewage can lead to sludge deposits and anaerobic conditions in receiving surface waters [9]. The methods of determination are based on the amount of oxygen required to convert oxidizable materials to stable end products. Since the oxygen used is proportional to the oxidizable materials present in the sewage, oxygen measurement therefore serves as a relative measure of the strength of domestic sewage [1].

II. Justification of the Study

Suspended solids and permanganate values are pollution characteristics used to assess the pollution strength of domestic sewage [8].

The suspended solids present in domestic sewage are insoluble organic and inorganic particles. They are mainly materials that are too small to be collected as solid wastes. They do not settle in the classifier either. Discharge of suspended solids increases the turbidity of water and causes a long term demand for oxygen because of the slow degradation rate of the organic fraction of the material. This organic

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material may consist of fat, proteins and carbohydrates [10].

The natural biodegradation of proteins (e.g. milk, eggs, meat etc.) will eventually lead to the discharge of ammonia. Ammonium oxidation into nitrite and nitrate by nitrifying bacteria lead to an extra consumption of oxygen present in the sewage. The amount of suspended solids in waters therefore increases with the degree of water pollution [11].

Permanganate value is a measure of the amount of oxygen obtainable from potassium permanganate needed for the oxidization of easily oxidizable inorganic and organic pollutants present in sewage samples [12].

In acid or alkaline solution, potassium permanganate releases oxygen for oxidation purposes. When a sample is exposed to a dilute solution of acidified potassium permanganate ($KMn0_4$) in a stoppered bottle, the acidified solution of $KMn0_4$ releases oxygen which oxidizes easily oxidizable wastes in the sample.

$$2Mn0_4^- + 6H^+ \longrightarrow 2Mn^{2+} + 3H_20 + 5\,(0)$$

$$2Mn0_4^- + 20H^- \longrightarrow 2Mn0_2 + H_20 + 5\,(0)$$

the unused potassium permanganate can therefore be determined by adding to it excess potassium iodide solution from where equivalent quantity of iodide is then titrated against standard sodium thiosulphate solution [13].

$$2Mn0_4^- + 16H^+ + 10I^- \longrightarrow 2Mn^{2+} + 8H_20 + 5I_2$$

III. Objectives of the Study

The objectives of this study are to:

i) Determine the concentration of suspended solids and permanganate values of raw domestic sewage

ii) Study the relationship between the two pollution characteristics mentioned above

iii) Establish the relationship which may be found to exist between the suspended solids and permanganate value in the domestic sewage.

IV. Materials and Methods

a) Raw domestic sewage used

The raw sewage was collected from a steady stream of sewage arriving at a Sewage Treatment Plant through a conventional central sewerage system (CSS) in an Estate in Warri, Delta State, Nigeria.

V. Sampling Techniques

Samples were obtained from the treatment plant every week. Six samples were collected per day at one hour intervals starting at 7.00am and ending at 12.00pm. Sampling was most convenient during this period.

Each sample was collected in a clean, well labeled plastic bottle and kept in a refrigerator maintained at 4^0C. At this temperature, biodegradation is inhibited.

The rate of flow was determined with a flow meter each time a sample was collected. At the end of the sampling period, a composite sample was made by adding together volumes of samples proportional to the rate of flow. The samples were collected in wet and dry seasons which are the major seasons in Nigeria so that the results obtained could give a detailed account of the suspended solids concentration and the permanganate value of the sewage in both seasons. Sewage samples were obtained in the wet season months from April to October and in the dry season months from November to March. The composite samples obtained were used for the determination of the suspended solids and permanganate value.

VI. Determinations

The two characteristics were determined as recommended by the Standard Methods for the Examination of Water and Wastewater [14], Standard methods for Water and Effluents Analysis [13] and Bureau of Indian Standards [15].

a) Data Analysis

The results obtained were subjected to statistical analysis so as to ascertain whether a significant relationship exists between suspended solids and permanganate values. A correlation and regression test was used to analyse any relationship between SS and PV. Assuming the pairs of characteristics SS and PV are represented as x and y. The regression equation of y on x for PV and SS was represented as $y = ax + b$ [16], [17] where a and b are constants; a being the slope and b, the intercept on the y axis. The correlation coefficient, r was calculated [18], [19]. The mean values of x and y and also the standard deviations were calculated [20].

VII. Results and Discussion

Results of the sewage analysis obtained for SS and PV determinations are as shown in Tables 1-3.

Table 1 : Results of sewage analysis of SS and PV (Mean values of triplicate determinations for the wet season months).

SAMPLE NO.	MONTHS	SS (≡x) mg/l MEAN ± SD	PV (v≡y) mg/l MEAN ± SD
1	APRIL	380.00±1.89	286.00±34.10
2	MAY	260.00±2.11	194.80±0.43
3	JUNE	240.00±271	166.40±1.26
4	JULY	200.00±2.31	162.20±0.80
5	AUGUST	250.00±189	175.80±5.12
6	SEPTEMBER	256.00±2.98	219.27±0.85
7	OCTOBER	260.00±4.99	217.27±0.19

The results in Table 1 depicts the mean values and standard deviations obtained for SS and PV at the studied site between the months of April and October which represented the wet season months. The essence of this is to know the status of the sewage from the treatment plant during the wet season.

Table 2 : Results of sewage analysis of SS and PV (Mean values of triplicate determinations for the dry season months).

SAMPLE NO	MONTHS	SS (≡ x) mg/l MEAN ± SD	PV (≡ y) mg/l MEAN ± SD
1	NOVEMBER	200.00 ± 2.83	165.00 ± 0.85
2	DECEMBER	214.00 ± 9.09	168.53 ± 0.44
3	JANUARY	220.00 ± 11.03	182.73 ± 0.64
4	FEBRUARY	250.00 ± 1.33	202.73 ± 0.34
5	MARCH	280.00 ± 6.11	218.40 ± 0.57

Table 2 depicts the mean values and standard deviations of SS and PV at the studied site between the months of November and March which represented the dry season months.

Table 3 : Results of sewage analysis showing suspended solids concentration and permanganate values (Mean values for the whole year).

SAMPLE NO	MONTHS	SS (≡ x) mg/l MEAN ± SD	PV (≡ y) mg/l MEAN ± SD
1	APRIL	380.00 ± 1.89	286.00 ± 34.10
2	MAY	260.00 ± 2.11	194.80 ± 0.43
3	JUNE	240.00 ± 271	166.40 ± 1.26
4	JULY	200.00 ± 2.31	162.20 ± 0.80
5	AUGUST	250.00 ± 189	175.80 ± 5.12
6	SEPTEMBER	256.00 ± 2.98	219.27 ± 0.85
7	OCTOBER	260.00 ± 4.99	217.27 ± 0.19
8	NOVEMBER	200.00 ± 2.83	165.00 ± 0.85
9	DECEMBER	214.00 ± 9.09	168.53 ± 0.44
10	JANUARY	220.00 ± 11.03	182.73 ± 0.64
11	FEBRUARY	250.00 ± 1.33	202.73 ± 0.34
12	MARCH	280.00 ± 6.11	218.40 ± 0.57

Table 4 : Data analysis of PV on SS (for the whole year).

		SS (mg/l)		PV (mg/l)		
SAMPLE NO.	MONTHS	X	X^2	Y	Y^2	XY
1	APRIL	380.00	144400.00	286.00	81796.00	108680.00
2	MAY	260.00	67600.00	194.80	37947.04	50648.00
3	JUNE	240.00	57600.00	166.40	27688.96	39936.00
4	JULY	200.00	40000.00	162.20	26308.84	32440.00
5	AUGUST	250.00	62500.00	175.80	30905.64	43950.00
6	SEPTEMBER	256.00	65536.00	219.27	48079.33	56133.12
7	OCTOBER	260.00	67600.00	217.27	47206.25	56490.20
8	NOVEMBER	200.00	40000.00	165.00	27225.00	33000.00
9	DECEMBER	214.00	45796.00	168.53	28402.36	36065.42
10	JANUARY	220.00	48400.00	182.73	33390.25	40200.60
11	FEBRUARY	250.00	62500.00	202.73	41099.45	50682.50
12	MARCH	280.00	78400.00	218.40	47698.56	61152.00
SUM		3010.00	780332.00	2359.13	477747.69	609377.84
MEAN		**250.83.00**		**196.59**		

Table 3 shows the SS and PV results and thus the status of the sewage from the treatment plant for the whole year. Analysis of the results obtained in Tables 1-3 is as shown in Table 4 below. The essence of the analysis is to establish whether there is a relationship between these two characteristics during the wet season, dry season and the entire year. The PV and SS values were determined in both wet and dry seasons so as to examine the pollution strength of both characteristics in the domestic sewage for the whole year.

The results obtained from the analysis reflect the degree of correlation between the suspended solids and permanganate value determined. A comparison of the results in Tables 1 and 2 reveals the effects of both wet and dry seasons on the SS and PV levels in the domestic sewage.

The SS levels ranged between 200.00mg/l and 380.00mg/l, while PV levels ranged between 162.20mg/l and and 286.00mg/l in the wet season months(Table 1). During the dry season months, SS levels ranged between 200.00mg/l and 280.00mg/l while PV levels ranged between 165.00mg/l and 218.40 mg/l(Table 2). This shows that high values occurred for both parameters during wet season while low values were observed for the parameters during dry season.

The high values which occurred for both parameters in the wet season months means that storm water washes various materials (debris, etc.) into the open collection chamber of the treatment plant during rainfall. The debris being washed in will affect the concentration of the parameters determined. The low values recorded for SS and PV in the dry season months show that no debris was washed into the open collection chamber of the treatment plant. The nature, quality and quantity of debris washed into the open collection chamber in each month and the intensity of rainfall would also have taken toll on the PV and SS levels.

The Linear regression of PV on SS for the wet and dry season months are as shown in Figures 1 to 3 below:

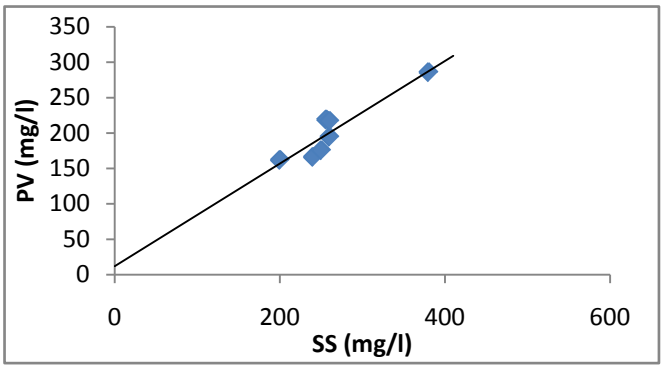

Figure 1 : Linear regression of PV on SS for wet season.

PV = a SS + b
PV= 0.72SS + 12.05
r = 0.9304

Key
SS = Suspended Solids
PV = Permanganate Value
a = Slope
b = Intercept
r = correlation coefficient

a) Wet season months

Figure 1 shows the relationship between permanganate value and suspended solids during the wet season. The resulting linear equation was PV = a SS + b. The slope of the graph a, was 0.72 and intercept on the PV axis b, was 12.05mg/l. Also the correlation coefficient r, was 0.9304.The value of the correlation coefficient (r = 0.9304), showed that the relationship between PV on SS for the wet season was real, strong and positive.

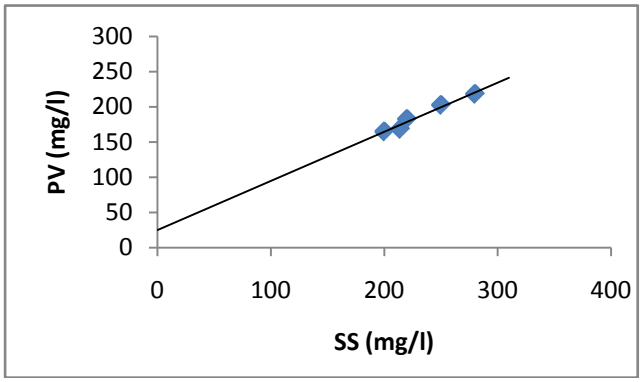

Figure 2 : Linear regression of PV on SS for dry season.

PV = a SS + b	Key
PV= 0.70SS + 24.84	SS = Suspended Solids
r = 0.9839	PV = Permanganate Value
	a = Slope
	b = Intercept
	r = correlation coefficient

b) Dry season months

Figure 2 shows the relationship between permanganate value and suspended solids during the dry season.

The Linear equation was PV = a SS + b. the slope of the graph (a) was 0.70 and the intercept (b) on the PV axis was 24.84. The correlation coefficient (r) was 0.9839. This showed strong positive correlation.

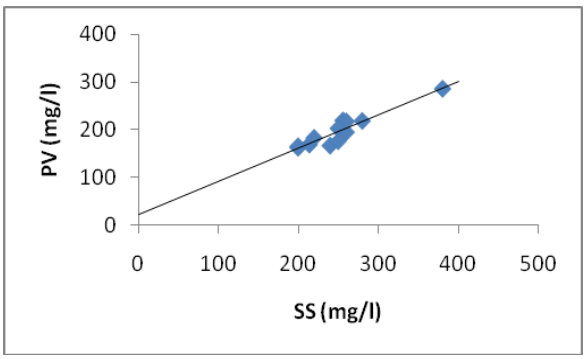

Figure 3 : Linear regression of PV on SS for the whole year.

PV = a SS + b	Key
PV= 0.70SS + 21.97	SS = Suspended Solids
r = 0.9377	PV = Permanganate Value
	a = Slope
	b = Intercept
	r = correlation coefficient

c) The whole year

Figure 3 shows the relationship between permanganate value and suspended solids for the whole year.

The slope of the graph (a) was 0.70, the intercept on the PV axis (b) was 21.97mg/l and the correlation coefficient (r) was 0.9377. This also showed strong positive correlation between permanganate value, PV and suspended solids, SS for the whole year. The linear regression equation was PV = a SS+ b.

The linear regressions of PV on SS for the three sections discussed above show high positive correlation. This is significant. The permanganate value reflects the amount of solids present in the system which will be acted upon by the readily available potassium permanganate (i.e. $KMn0_4$).

The magnitude of the permanganate value obtained depends on the suspended solids present in the sewage and this also depends on the pollution load. Permanganate value therefore provides information about how much suspended solids are present in the sewage sample.

VIII. Conclusion

In conclusion, the preceding analysis and discussion show that a real, strong and significant relationship exists between permanganate value (PV) and suspended solids (SS).

The linear regression equation is:

$$PV = 0.70\ SS + 21.97$$

Where PV represents permanganate value (mg/l) and SS represents suspended solids (mg/l). From the above equation, it can be established that:

$$SS = \frac{PV - 21.97}{0.70}$$

The regression equation shows that a relationship exists between the suspended solids and the permanganate value in the domestic sewage.

References Références Referencias

1. J.G. Henry, G.W. Heinke, Environmental Science and Engineeing. Prentice Hall, Eaglewood Cliffs, N. J. p 414(1989).
2. Septic Systems, EPA. United States Environmental Protection Agency (2011).
3. C.M.A Ademoroti, Environmental Chemistry and Toxicology. Foludex Press Ltd. Ibadan pp 80-83 (1996a).
4. I.E. Uwidia, C.M.A Ademoroti, Characterisation of Domestic Sewage from an Estate in Warri, Nigeria. Int. J. Chem. **3**:3 (2011).
5. H. Fish, Freshwaters in "Understanding Our Environment: An Introduction to Environmental

Chemistry and Pollution" ed. R.M. Harrison. Royal Society of Chemistry Cambridge, UK. pp 53-91 (1994).

6. G. Tchnobanoglous, F.L. Burton, H.D. Stensel, Wastewater Engineering (Treatment, Disposal, Reuse), 4th Edition, Metcalf and Eddy Inc. McGraw-Hill Book Co p 134 (2003).
7. M. Csuros, Environmental Sampling and Analysis. CRC Press LLC, New York, pp 215-216 (1997).
8. R. Miroslav, B.N. Vladimir, Practical Environmental Analysis. The Royal Society of Chemistry. Cambridge, Uk p 163 (1999).
9. R.F. Packham, Water Quality and Health. 2nd Edition, Royal Society of Chemistry, Cambridge, U.K, (1990).
10. A. Ward, W.Elliot, Environmental Hydrology. Lewis (CRC Press), New York. p 65 (1995).
11. R. Moldan, J. Cherry, Biogeochemistry of small Catchments, scope 51, Wiley and Sons, New York, pp 164-188, 2007-223 (1994).
12. I.E. Uwidia, Prediction of Five-Day Biochemical Oxygen Demand (BOD_5) Values from More Readily Determinable Pollution Characteristics. PhD Thesis, University of Benin, Benin City, p. 42 (2011).
13. C.M.A. Ademoroti, Standard Methods for Water and Effluents Analysis. Foludex Press Ltd. Ibadan, pp 22 -23, 44-49 (1996b).
14. American Public Health Association. Standard Methods for the Examination of Water and Wastewater 19th Edition. American Public Health Association, New York, pp 5210A-B (1995).
15. Bureau of Indian Standards (BIS), Methods of sampling and Test for Water and Wastewater 1st Revision of 15 30025 ICS No. 13.060.50, pp1.-3 (2005).
16. Tofallis, Least Square Percentage Regression J. Modern Appl. Statistical Methods **7**:526-534 (2009).
17. J. Cohen, P. Cohen, S.G. West, L.S. Aiken, Applied Multiple Regression / Correlation Analysis for the Behavioral Sciences. 2nd Edition. Hillside, NJ, Lawrence Erlbaum Associates. (2003).
18. T.K Nathabandv, R. Renzo, Statistics and Probability for Civil and Environmental Engineers. McGraw-Hill Book Co.Surgapore pp 246-355 (1998).
19. Mathbits.com/mathbits/tisection/statistic2/correlation.htm.(2000 MathBits.com).
20. J.N.Odili, H.N. Ajuar, Basic Educational Measurement and Evaluation. 2nd Edition, COEWA Publishers, Warri, Nigeria pp.110 -117 (1995).

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Fabrication & Testing of Rapid Sand Filter Equipment

By Dr.K.Mahammad Rafi, T.Ramachar, Dr.M.Umamahesh & Mr.B.Arun Babu

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Abstract - Water is described as a universal solvent which is the most abundant and useful compound that nature has provided. Two main sources of water are: surface and underground water. Among the many essential elements for the existence of human beings, animal and plants, water is rated as one of the most important elements for human living. Man can survive for weeks without food but a few days without water.

Sand has been used to purify water for over a thousand years; and it still remains the dependable methods of making water fit for drinking. The idea of water sand filtration can be seen when water taken from sandy river beds is generally pure, because it has percolated through the sand grains where harmful bacteria are removed.

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Fabrication & Testing of Rapid Sand Filter Equipment

Dr.K.Mahammad Rafi [α], T.Ramachar [σ], Dr.M.Umamahesh [ρ] & Mr.B.Arun Babu [ω]

Abstract - Water is described as a universal solvent which is the most abundant and useful compound that nature has provided. Two main sources of water are: surface and underground water. Among the many essential elements for the existence of human beings, animal and plants, water is rated as one of the most important elements for human living. Man can survive for weeks without food but a few days without water.

Sand has been used to purify water for over a thousand years; and it still remains the dependable methods of making water fit for drinking. The idea of water sand filtration can be seen when water taken from sandy river beds is generally pure, because it has percolated through the sand grains where harmful bacteria are removed.

As a result of high demand for quality and clean water by the society, various means to meet this demand have been constructed. Though, many of these means are not easily accessible by some communities, due to unavailability, high cost, or complexity of usage. This has led to the design and construction of water filters which can be accessible by all communities. Data obtained from our laboratory results clearly shows that an appreciable degree of treatment had taken place when the designed filter was used. in this paper we describes the fabrication rapid sand filteration equipment by using glass boxes, sand. Activated carbon, mesh, coagulant etc .and also tested the raw water & treated water byu using WHO standard analytical procedures.

I. Introduction

Unsafe drinking water, along with poor sanitation and hygiene, accounts for nearly 10% of the total burden of disease worldwide. This includes an estimated 4 billion cases of diarrhea disease annually, causing 1.8 million deaths, mostly among children under 5 years of age. By affecting normal consumption of foods and reducing the adsorption of nutrients, diarrheal diseases are also an important cause of malnutrition, which can lead to impaired cognitive development and physical growth, reduced resistance to infection, and potentially, long-term gastrointestinal disorders. Contaminated water is also an important contributor to other potentially waterborne diseases, including hepatitis A and E, cholera, typhoid, and poliomyelitis.

II. Literarture Review

The kind of treatment water needs strongly depends upon the composition and quality of the water. Water treatment contains two process steps: physical removal of solid particles, mainly minerals and organic matter and chemical disinfection; killing or deactivating micro organisms in water.

Since water contains no calories and can serve as an appetite suppressant and helps the body metabolize stored fat, it may possibly be one of the most significant factors in losing weight. In his book, titled "The Snowbird Diet" Dr. Donald Robertson says the body will not function properly without enough water and discusses the importance of drinking plenty of water for permanent weight loss: "Drinking enough water is the best treatment for fluid retention; the overweight person needs more water than the thin one; water helps to maintain proper muscle tone; water can help relieve constipation; drinking water is essential to weight loss." Water is a key component in determining the quality of our lives. Today, people are concerned about the quality of the water they drink. Although water covers more than 70% of the Earth, only 1% of the Earth's water is available as a source of drinking. Yet, our society continues to contaminate this precious resource. Water is known as a natural solvent. Before it reaches the consumer's tap, it comes into contact with many different substances, including organic and inorganic matter, chemicals, and other contaminants. Many public water systems treat water with chlorine to destroy disease-producing contaminants that may be present in the water. Although disinfection is an important step in the treatment of potable water, the taste and odor of chlorine is objectionable. And, the disinfectants that are used to prevent disease can create byproducts which may pose significant health risks. Today, drinking water treatment at the point-of-use is no longer a luxury, it is a necessity! Consumers are taking matters into their own hands and are now determining the quality of the water they and their families will drink by installing a drinking water system that will give them clean, refreshing, and healthier water.

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In our country most of the people are drinking non potable water. By consumption of this water leads to human health problems.

a) Types of filters

i. *Slow sand filter*

Slow sand filters are used in water purification for treating raw water to produce a potable product. They are typically 1 to 2 meters' deep, can be rectangular or cylindrical in cross section and are used primarily to treat surface water. The length and breadth of the tanks are determined by the flow rate desired by the filters, which typically have a loading rate of 0.1 to 0.2 meter per hour (or cubic meter per square meter per hour). Slow sand filters now are also being tested for pathogen control of nutrient solutions in hydroponic systems

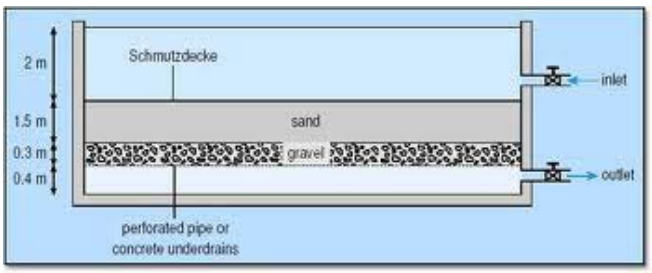


Fig. 1 : slow sand filters

1. Water from the North Santiam is put on slow sand filters.
2. Algae, protozoa, and small invertebrates that live in the slow sand filter remove biological contaminants such as Cryptosporidium. The surface of the slow sand filter is where most of the contaminant removal occurs.
3. Straining of dirt and clay particles occurs at the surface of the filter as well as further down through the sand and gravel.
4. After water passes through the slow sand filter, chlorine is added for disinfection, and soda ash is added for corrosion control.

Advantages

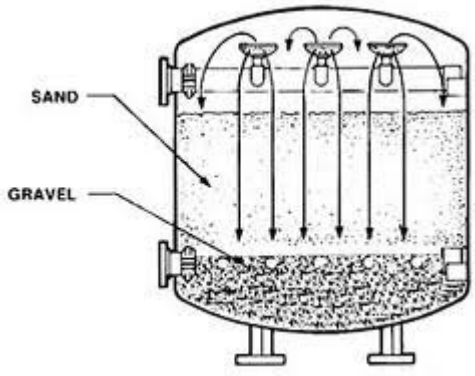
There are several advantages of slow sand filtration over other methods of water disinfestations:

- It is a low energy consuming process
- It has great adaptability in components and applications maintenance is minimal
- Systems can be built and installed by laymen
- Costs of building and running significantly lower than other disinfestation methods

Disadvantages

- Due to the low filtration rate, slow sand filters require extensive land area for a large municipal system.
- Many municipal systems in the U.S. initially used slow sand filters, but as cities have grown they subsequently installed rapid sand filers, due to increased demand for drinking water.

ii. *Rapid sand gravity filter*



The **rapid sand filter** or **rapid gravity filter** is a type of filter used in water purification and is commonly used in municipal drinking water facilities as part of a multiple-stage treatment system.

Rapid sand filters use relatively coarse sand and other granular media to remove particles and impurities that have been trapped in a flock through the use of flocculation chemicals--typically salts of aluminium or iron. Water and flock flows through the filter medium under gravity or under pumped pressure and the flocculated material is trapped in the sand matrix.

Mixing, flocculation and sedimentation processes are typical treatment stages that precede filtration. Chemical additives, such as coagulants, are often used in conjunction with the filtration system

Advantages

- Much higher flow rate than a slow sand filter; about 150 to 200 million gallons of water per acre per day
- Requires relatively small land area
- Less sensitive to changes in raw water quality, e.g. turbidity
- Requires less quantity of sand

Disadvantages

- Requires greater maintenance than a slow sand filter. For this reason, it is not usually classed as an "appropriate technology," as the term is applied in less-developed countries.
- Generally ineffective against taste and odor problems.
- Produces large volumes of sludge for disposal.
- Skilled supervision is essential.
- Cost of maintenance is higher. It cannot remove bacteria.

III. Experimental

a) Fabrication of rapid sand filter

The equipment consists of three boxes having side 25 cm of cube. The First glass box and second

glass box consists of 3 cm thickness fiber box. In that fiber box contains double layer cloth mesh; on it 2 cm thickness of sand layer is placed. On the sand layer aluminum mesh is kept, 0.5 cm thickness of Gravel is placed on the aluminum mesh and Activated carbon of 0.5 cm is kept on it, 5 gm of aluminum oxide crystals are placed on activated carbon.

Third glass box is used to store water. From third glass box a booster pump is connected for collecting the water.

b) Working of rapid sand filter (RSF)

The collected water is allowed in the top glass box of the system. The water passes through aluminum oxide and activated carbon. Then this water reacts with activated carbon which is negatively charged, by this oxidation will be done.

After this the water passes through gravel where large particles will be filtered then water will pass through aluminum mesh and then to sand membrane here small size particles will be filtered, then water will pass through the cotton cloth meshes here very small size particles are filtered from the water .

Then the water flows through the holes of first glass box and fell into the second glass box. Here the same process will be repeated as in the first glass box.

Then the water flows from second glass box and fell into the third glass box. From third glass box the water is pumped by the booster pump and that water is collected and tested.

Also Reverse osmosis membrane (RO), (in which large molecules and ions are removed from solution by applying pressure to the solution) is also used for testing the water. The water passed through the RO membrane is collected and tested.

A taste chamber is used to add taste to water. The collected water is analyzed by using WHO standard analytical procedures.

The all connections are done with the help of 1 cm diameter pipes between boxes and Booster pump, RO membrane, taste cartridge etc.

c) Testing method, results & disscution

The raw water is passed through i) RSF ii) RO & iii) Both RSF & RO and tested.

The fig 3.3.1 shows Rapid sand filter, Fig 3.3.2 shows Reverse Osmosis and Fig. 3.3.3 shows Rapid sand filter with RO.

Fig 3.3.1 : Rapid sand filter.

Fig 3.3.2 : Reverse Osmosis.

Fig. 3.3.3 : Rapid sand filter with RO.

The raw water (RW) and the treated water (TW) are analyzed for water quality parameters and results are shown in below table 3.3.1 & table3.3.2.

From the results in table 3.3.1 the Electrical conductivity, TDS, Total Solids, Turbidity, Hardness, Alkalinity & Residual chlorine are within the limits specified by IS standards for the water treated by the system without RO membrane when compared to raw water. But DO decreases below the limit specified by IS system.

Also the water quality parameters of the water treated by RO alone are not within the limits.

Table 3.3.1 : Results of RO and RSF

Further analysis is carried to find the effect of RSF with RO membrane. The results are shown in Table 3.3.2.

S.NO	NAME	pH	EC (Mho/cm)	TDS (mg/l)	TS (mg/l)	TURBIDITY (mg/l)	DO (mg/l)	HARDNESS (mg/l)	ALKALINITY (mg/l)	RESIDUAL CHLORINE	F^-
1	R W	8.3	2.340	2983	3627	16.4	7.78	1123	892	1.26	1.42
	T W	7.6	1.450	1206	1482	8.9	2.59	469	426	0.63	1.12
2	R W	8.4	2.560	3057	3780	16.9	7.84	1149	889	1.32	1.54
	T W	7.5	1.490	1233	1398	9.1	3.2	473	420	0.71	1.24
3	R W	7.5	1.848	1242	9.2	9.2	3.2	940	1023	1.1	0.42
	T W	7.1	0.973	623	716	4.3	2.4	390	420	0.52	0.36
4	R W	7.9	1.676	1642	1863	11.2	4.9	862	966	0.9	0.96
	T W	7.2	0.826	934	1076	6.4	3.6	374	426	0.56	0.72
5	R W	7.6	1.167	1250	1592	10.9	4.2	796	874	0.86	0.96
	T W	6.8	0.742	649	864	5.2	2.9	387	399	0.52	0.76

From the results in table 3.3.2, the Electrical conductivity, TDS, Total Solids, Turbidity, Hardness, Alkalinity & Residual chlorine are within the limits specified by IS standards for the water treated by the system when compared to raw water. But DO decreases below the limit specified by ISO system.

Table 3.3.2 : Results of RO & RSF combined

S.no	Name	PH	EC	TDS	TS	Turbidity	Do	Hardness	Alkalinit	Residua Chlorine	F^-
1	R W	8.2	2.3	3106	3492	16	7.6	1110	882	1.2	1.4
2	RO	8.0	2.1	2634	2752	14.2	6.8	739	690	0.89	1.34
3	RSF with RO	7.7	1.6	1849	1923	9.5	3.9	540	512	0.63	1.2

According to results from table 3.3.1 the values of Treated Water with RO is reduced to 15-20% and the Treated Water without RO is reduced to 30- 40%. And by using both the values reduced to 50-60% from table 3.3.2.

IV. Conclusions

The following conclusions can be made from this research. The Rapid sand filtration method is the most suitable among several treatment processes, locally available materials were used in the construction, the depth and capacity of filter bed were increased which made it to be more efficient to an appreciable degree. In conclusion, despites the fact that water gotten from the tap has undergone some treatments, it still needs to be filtered for it to be safe for drinking. An efficient filter tank having more capacity using rapid sand filtration method with inclusion of activated charcoal and the filter bed length increased have been produced.

References Références Referencias

1. Anderson, P. 2003: *Environment Sanitation Manual*. Department of Aquatic Biology, Exeter University: England.

2. Camp, T.R. 1999. *Water Treatment Handbook of Hydraulic. 2nd Edition*. McGraw Hill: New York, NY. 30
3. Charles, B. 2001. *Water Supply and Sanitation*. The Hague, Netherlands. 22-26.
4. Charles, R.C. 1973. *Operation and Control of Water treatment. 3rd Edition*. World Health Organization: Geneva, Switzerland. 30.
5. Fill Tech Corp. 1989. *Reverse Osmosis System*. Film Tech Corp Ltd.: New York, NY.
6. Adekunle, A.A. and S.B. Adejuyigbe. 2011. "Fabrication of Plastic Water Filter and Testing with Slow Sand Filtration". *Pacific Journal of Science and Technology*. 13(1):121-132
7. Stumm, W., Morgan, J.J., (1996), Aquatic Chemistry, 3rd Ed. Wiley-Interscience Publication. Envieonmental Protection Agency (USEPA), (2003). Chemical contaminants in drinking water. Technical fast sheet on microbes. EPA 816-03-016.
8. World Health Organization, (WHO), (2003). Guidelines for drinking water quality. Geneva., (WHO/SDE/WSH 03. 04).
9. Miller, J.C, Miller, J.N., (1988), Statistics for analytical chemistry, Ellis Horwood Limited, Chichester. Singh1, S., Mosley, L.M., (2003). Trace metal levels in drinking water on Viti Levu, Fiji Islands. South Pacific Journal of Natural Science (S. Pac. J. Nat. Sci)., 21, 31-34.
10. Anawara, H.M., Akaib, J., Mostofac, K.M.G., Safiullahd, S.,Tareqd, S.M., (2002). Arsenic poisoning in groundwaterhealthrisk and geochemical sources in Bangladesh. Environ.Int., **27**,597-604.

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23. Multitasking in research is not good: Doing several things at the same time proves bad habit in case of research activity. Research is an area, where everything has a particular time slot. Divide your research work in parts and do particular part in particular time slot.

24. Never copy others' work: Never copy others' work and give it your name because if evaluator has seen it anywhere you will be in trouble.

25. Take proper rest and food: No matter how many hours you spend for your research activity, if you are not taking care of your health then all your efforts will be in vain. For a quality research, study is must, and this can be done by taking proper rest and food.

26. Go for seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

27. Refresh your mind after intervals: Try to give rest to your mind by listening to soft music or by sleeping in intervals. This will also improve your memory.

28. Make colleagues: Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

29. **Think technically:** Always think technically. If anything happens, then search its reasons, its benefits, and demerits.

30. Think and then print: When you will go to print your paper, notice that tables are not be split, headings are not detached from their descriptions, and page sequence is maintained.

31. Adding unnecessary information: Do not add unnecessary information, like, I have used MS Excel to draw graph. Do not add irrelevant and inappropriate material. These all will create superfluous. Foreign terminology and phrases are not apropos. One should NEVER take a broad view. Analogy in script is like feathers on a snake. Not at all use a large word when a very small one would be

sufficient. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Amplification is a billion times of inferior quality than sarcasm.

32. Never oversimplify everything: To add material in your research paper, never go for oversimplification. This will definitely irritate the evaluator. Be more or less specific. Also too, by no means, ever use rhythmic redundancies. Contractions aren't essential and shouldn't be there used. Comparisons are as terrible as clichés. Give up ampersands and abbreviations, and so on. Remove commas, that are, not necessary. Parenthetical words however should be together with this in commas. Understatement is all the time the complete best way to put onward earth-shaking thoughts. Give a detailed literary review.

33. Report concluded results: Use concluded results. From raw data, filter the results and then conclude your studies based on measurements and observations taken. Significant figures and appropriate number of decimal places should be used. Parenthetical remarks are prohibitive. Proofread carefully at final stage. In the end give outline to your arguments. Spot out perspectives of further study of this subject. Justify your conclusion by at the bottom of them with sufficient justifications and examples.

34. After conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print to the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects in your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form, which is presented in the guidelines using the template.
- Please note the criterion for grading the final paper by peer-reviewers.

Final Points:

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

The introduction will be compiled from reference matter and will reflect the design processes or outline of basis that direct you to make study. As you will carry out the process of study, the method and process section will be constructed as like that. The result segment will show related statistics in nearly sequential order and will direct the reviewers next to the similar intellectual paths throughout the data that you took to carry out your study. The discussion section will provide understanding of the data and projections as to the implication of the results. The use of good quality references all through the paper will give the effort trustworthiness by representing an alertness of prior workings.

Writing a research paper is not an easy job no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record keeping are the only means to make straightforward the progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

- Insertion a title at the foot of a page with the subsequent text on the next page

- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

· Use standard writing style including articles ("a", "the," etc.)

· Keep on paying attention on the research topic of the paper

· Use paragraphs to split each significant point (excluding for the abstract)

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

· Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives

· Shun use of extra pictures - include only those figures essential to presenting results

Title Page:

Choose a revealing title. It should be short. It should not have non-standard acronyms or abbreviations. It should not exceed two printed lines. It should include the name(s) and address (es) of all authors.

Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing references at this point.

An abstract is a brief distinct paragraph summary of finished work or work in development. In a minute or less a reviewer can be taught the foundation behind the study, common approach to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than lone rationale. The author can at this moment go straight to

shortening the outcome. Sum up the study, with the subsequent elements in any summary. Try to maintain the initial two items to no more than one ruling each.

- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including definite statistics - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

Introduction:

The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.
- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose specifically - do not take a broad view.
- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

Procedures (Methods and Materials):

This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic

principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.

- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

Administration Rules Listed Before Submitting Your Research Paper to Global Journals Inc. (US)

Please carefully note down following rules and regulation before submitting your Research Paper to Global Journals Inc. (US):

Segment Draft and Final Research Paper: You have to strictly follow the template of research paper. If it is not done your paper may get rejected.

- The **major constraint** is that you must independently make all content, tables, graphs, and facts that are offered in the paper. You must write each part of the paper wholly on your own. The Peer-reviewers need to identify your own perceptive of the concepts in your own terms. NEVER extract straight from any foundation, and never rephrase someone else's analysis.

- Do not give permission to anyone else to "PROOFREAD" your manuscript.

- Methods to avoid Plagiarism is applied by us on every paper, if found guilty, you will be blacklisted by all of our collaborated research groups, your institution will be informed for this and strict legal actions will be taken immediately.)
- To guard yourself and others from possible illegal use please do not permit anyone right to use to your paper and files.

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Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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