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A NOVEL PROCESS OF WATER PURIFICATION SYSTEM FOR LARGE- SCALE PRODUCTIONS

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Abstract

Purification system has recently gained increasing importance, especially in water treatment systems. Biological water treatment systems with microalgae are now widely accepted. Moreover, algal wastewater treatment systems are effective when compared to conventional treatment systems. The proposed purification system aims to provide a process for using saline water, and saline reject water produced in water purification for gold mining production. Also, it provides a method for growing and harvesting algae utilizing saline water as growth medium for recycling waste water to extract the remaining metals from it. This trend of purification system using harvested algae has various applications, and may be used in wide aspects including, but not limited to, algae biomass production to extract metals, and reducing the cost of gold mining production.

Keywords: Purification system, gold mining, minerals extraction, algae biomass, photosynthetic, water treatment

1.0 INTRODUCTION

Algae are modest microbes with amazing potential. They thrive in turbid, brackish water environments with little more than basic nutrients and sunshine. They grow far more rapidly than conventional crops, and generate a much higher fraction of their biomass as oil (up to 60%, versus 2%-3% for soybeans).

As recently, algae have become significant organisms for biological purification of wastewater since they are able to accumulate plant nutrients, heavy metals, pesticides, organic and inorganic toxic substances and radioactive matters in their cells/bodies [1-4]. These specific features have made algal wastewaters treatment systems an significant low-cost alternatives to complex expensive treatment systems particularly for purification of municipal wastewaters.

In addition, algae harvested from treatment ponds are widely used as nitrogen and phosphorus supplement for agricultural purpose and can be subjected to fermentation in order to obtain energy from methane. Algae are also able to accumulate highly toxic substances such as selenium, zinc and arsenic in their cells and/or bodies thus eliminating such substances from aquatic environments. Radiation is also an important type of pollution as some water contains naturally radioactive materials, and others become radioactive through contamination. Many algae can take up and accumulate many radioactive minerals in their cells even from greater concentrations in the water [5]. MacKenthun emphasized that Spirogyra can accumulate radio-phosphorus by a factor 850.000 times that of water [6].

It is well known that algae have an important role in self purification of organic pollution in natural waters [7]. Moreover, many studies revealed that algae remove nutrients especially nitrogen and phosphorus, heavy metals, pesticides, organic and inorganic toxins, pathogens from surrounding water by accumulating and/or using them in their cells [8-9]. Also, studies showed that algae may be used successfully for wastewater treatment as a result of their bioaccumulation abilities [10].

Considering all these abilities of algae to purify the polluted waters of many types, it is worth to emphasize that algal technology in wastewater treatment systems are expected to get even more common in future years.

Wastewater treatment which is applied to improve or upgrade the quality of a wastewater involves physical, chemical and biological processes in primary, secondary or tertiary stages. Primary treatment removes materials that will either float or readily settle out by gravity. It includes the physical processes of screening, contamination, grit removal, and sedimentation. While the secondary treatment is usually accomplished by biological processes and removes the soluble organic matter and suspended solids left from primary treatment. Tertiary or advanced treatment is process for purification in which nitrates and phosphates, as well as fine particles are removed [11]. However initial cost as well as operating cost of wastewater treatment plant including primary, secondary or advanced stages is highly expensive [12].

The algae production industry is where the computer and software industry was in 1980 – about to explode. If all the potential uses of algae biomass as a substitute for other materials were to be realised, it would result in a $1.4-1.7 trillion a- year market.

Some algae produce lipids that can be converted to biodiesel or green diesel. Some strains produce ethanol. Algae biomass is also used as food, animal feed and fertiliser, but it isn't reasonable to expect 100% substitution – there are too many complications. In 20 years, for instance, you might expect to see fuel substitution in the 5%-8% range.

Creating biofuels from microbes has many advantages. Algae can grow in low lying areas unsuitable for conventional crops. Algae can yield 8,000 litres of fuel per acre per year, compared with 2,600 litres for palm oil and 200 litres for soy. Algae can use brackish water or wastewater as a growing medium, eliminating the freshwater needs of ethanol production. Importantly, algae production does not compete with food crops such as corn or soy for acreage, nutrients or fresh water. Furthermore, biofuels are similar enough to gasoline and diesel that they do not require special treatment during transportation and mixing at the refinery.

Recent studies conclude that this algae dewatering process costs over $3,000 in energy alone to produce one tonne of dry weight biomass equivalent, making algae an uneconomic source of fuel when compared to fossil fuels. Nevertheless, a comprehensive industry survey undertaken by the Algal Biomass Organization last year found that more than 35% of industry participants believe it is either very likely or extremely likely that algae-based fuels will be cost-competitive with fossil fuels by 2020.

1.1 Filtering the Flow

The economic and environmental incentive to reduce the energy costs associated with algae processing is driving increased levels of industry research, particularly on ways to reduce the cost of algae dewatering. Pall Corporation, for example, has developed the Algae Separation & Concentration Filter (ASCF). "The technology borrows from other applications where we use membranes for treating industrial wastewater, or wine production," says DiLillo. "It utilises a robust, hollow-fibre filter technology that can withstand the rigours of chemical cleaning that are used to remove organic and inorganic debris."

Most of the recent researches were on the using of microalgae for make wastewater treatment have been based on the use of a monoculture to remove a specific nutrient (mainly nitrogen or phosphate) and only a few studies have been reported on the use of mixed algal cultures for wastewater treatment.

Wastewater contains a diversity of nutrients and it is not easy to get a single strain that can simultaneously remove all the nutrients from the wastewater. In both activated sludge and oxidation pond processes, complex mixtures of natural populations of microorganisms are used and the composition and relative proportions of these microorganisms vary based on the composition of the wastewater and with the stage of treatment too.

Photosynthetic microorganisms are varying in their nutritional requirements and it is possible to select a good combination of photosynthetic microorganisms for simultaneous removal of different nutrients from wastewater.

1.2 Gold and Carbon in Detrital Deposits

One of the common associations with gold in detrital deposits is the association of gold with uranium and carbon. This holds true in the Witwatersrand and all the other gold deposits of a detrital nature. For many years the origin of the carbon was hotly debated with the most recent evidence holding that it is from primitive life forms that lived in the distant past in the Archean.

Algae exposed at the intertidal zone similar to the ancient algae that trapped gold. Even today this kind of mat could be a good place to search for gold. It has been posited that these algae formed great mats similar to stromatolites that acted as a trap for the gold particles and uranium minerals in the same manner that modern mats of algae work to snare gold particles in a modern environment. It is common practice to use an artificial mat of the same nature in a sluice box to entrap gold.

Even today if you encounter a mat of algae in the bottom of the stream or river is a good place to search for gold that has been caught in the mat by the action of running water.

At the time many of these gold bearing deposits were at the bottom of a braided stream channel that by being deposited in this manner explains the stringers of gold found in such a deposit. These stringers of gold are common in detrital gold deposits. Sometimes there is a layer of carbon that is as thin as a pencil line that is so richen gold and other minerals that they are mineable. In many detrital deposits the slim lines occur at a regular frequency to the extent that the entire deposit is mined so that I can undergo further ore dressing to free the gold so it can undergo even further treatment usually by being leached with a solution of cyanide.

Microalgae are considered as unique and potentially valuable microorganisms. In additions, they are the light-harvesting ‘‘cell factories’’ which convert carbon dioxide into biomass or a variety of bioactive compounds.

However many of them can grow heterotrophically, all microalgae are photoautotrophs, they require mainly sun, water, and inorganic nutrients for growth. When compared to higher plants, microalgae are simple in structure, being unicellular, filamentous or colonial, and energy is directed via photosynthesis into growth and reproduction; they do not need to establish and maintain complex tissues and organs [13].

Also, microalgae have the potential to produce valuable substances for the food, feed, cosmetic, pharmaceutical, and waste treatment industries [12–22]. More recently these photosynthetic microbes have also become the focus of considerable attention as a potential source of oils for biodiesel production [23–26].

In fact, the cultivation and harvest of products from microalgae has resulted in an increased commercial interest in their biotechnology because algae offer a number of advantages from an industry perspective. These include ease of culture and harvesting of products [13], greater photosynthetic efficiency than terrestrial plants [27], higher biomass productivities, faster growth rates than higher plants, and higher rates of CO2 fixation and O2 production [26].

The few commercial species that are currently being successfully cultured in large open ponds are extremophiles growing in a highly selective environment (high pH, salinity, or temperature). These conditions preclude the growth of most other algae and even many bacteria.

For the future of microalgal biotechnology, although, it remains important to develop large-scale photobioreactors that can be operated under defined, optimal conditions with capability for sterilization, and with minimal contamination risks.

However it is difficult to compare open ponds with closed systems or with indoor photobioreactors, the general consensus suggests that open systems could predominate for mass cultivation of algae for low value products like biofuels, while photobioreactors will be more useful for production of high value products such as therapeutics [28].

1.3 Photosynthetic Microorganisms

Many photosynthetic microorganisms are capable of metabolizing various types of organic acids, nitrogen and phosphate and their potential application in wastewater treatment has been mentioned by many authors [29-34].

An important advantage of using photosynthetic microorganisms for wastewater treatment is the possibility of combining wastewater treatment with useful metabolites production.

Algal biomass can be considered as an effective source of many useful metabolites [35], energy sources such as oil [36-37] and can also be used in removing toxic gases like NOX and SOX from flue gases [38-39].

Thus simultaneous wastewater treatment and useful metabolites production by cultivating photosynthetic cells on wastewater has been investigated [40-41].

Most of the studies on the use of microalgae for wastewater treatment have been depended on the use of monoculture to remove a specific nutrient (mainly nitrogen or phosphate) and only a few studies have been reported on the use of mixed algal cultures for wastewater treatment [42].

Many wastewater contains a variety of nutrients and it is not easy to get a single strain that can simultaneously remove all the nutrients from the wastewater. In both activated sludge and oxidation pond processes, complex mixtures of natural populations of microorganisms are involved and the composition and relative proportions of these microorganisms vary depending on the composition of the wastewater and also with the treatment stage.

Photosynthetic microorganisms are considered very diverse in their nutritional requirements and it is possible to choose a good combination of photosynthetic microorganisms for simultaneous removal of different nutrients from wastewater.

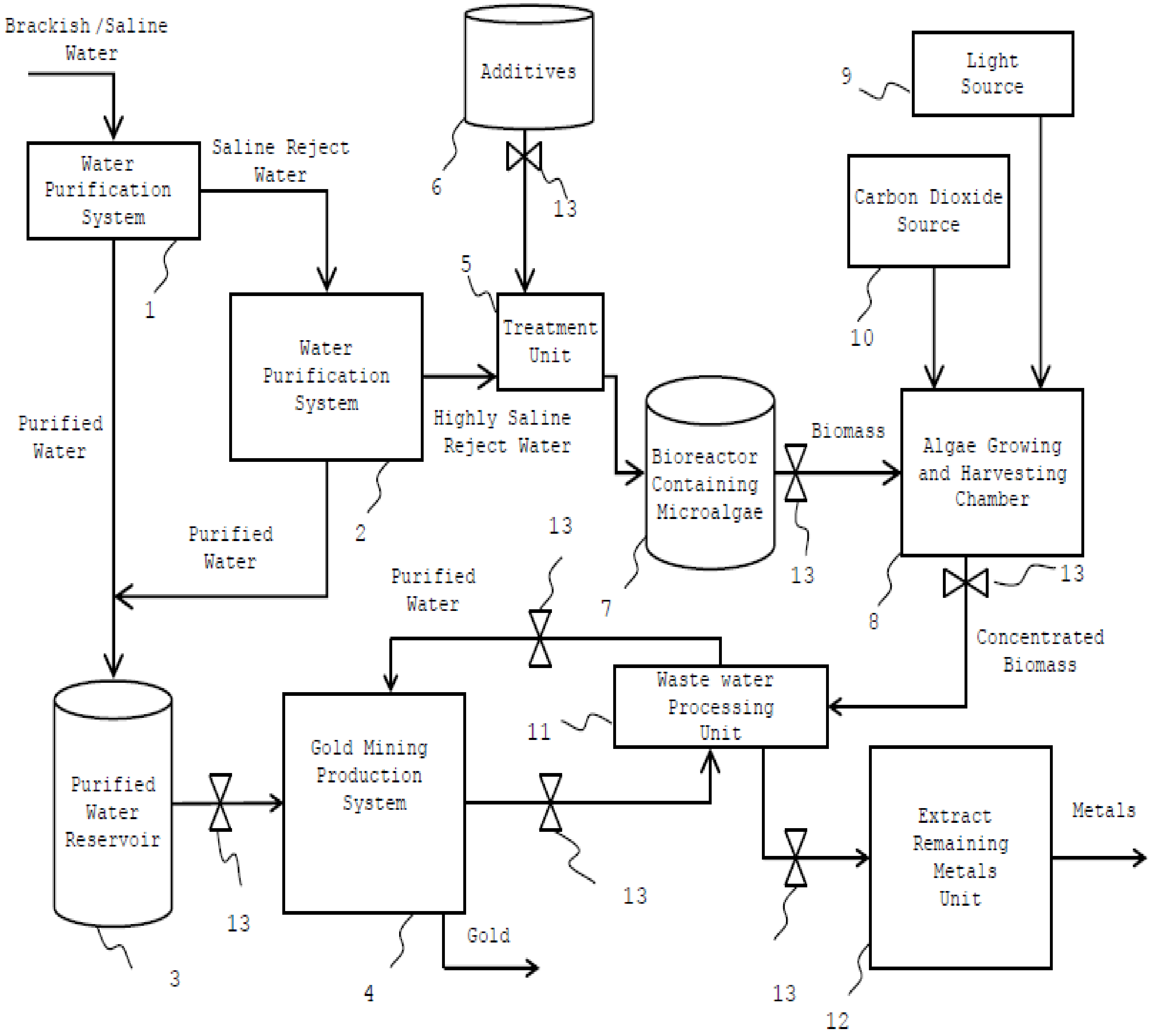

Figure 1 A process flow diagram for using Brackish/saline water for gold mining production

2.0 SYSTEM DESCRIPTION

The inland brackish water that constitute the feed for water purification plants has a higher quality (i.e. lower salinity) compared to seawater and is more suitable for water purification. Depending on level of salinity and cost, various methods are utilized for purifying the brackish water, such as reverse osmosis (RO), electro-dialysis reversal (EDR), or similar membrane techniques. Water purification process of brackish water produces purified water and saline reject water as main product and by-product, respectively. The produced saline reject water usually contains a higher concentration of various salts in water compared to the brackish water. A number of subsequent purifications may be performed to extract the remaining purified water from the saline reject water.

However, the salinity of the saline reject water increases after each subsequent purification, leading to increased cost, and complexity of the water purification procedure. Therefore, after a number of purification steps, the saline reject water becomes highly saline.

The highly saline reject water is considered as waste in the purification process and therefore is disposed. However, disposing such highly saline reject water is complicated and costly. Because of the costs and problems associated with the disposal of the highly saline reject water, there exists a need for developing methods for minimizing such undesirable liquid by-products, or recycling and/or transforming the waste into a valuable product. Moreover, extracting gold by using fresh water is expensive.

This system describes a method for using highly saline water, as an alternative to disposal, to produce a variety of valuable products such as gold mining production, and growing algae to extract Metals. In addition, it also recycles the waste water for the production of gold mining.

3.0 SYSTEM OBJECTIVE

The objective of the proposed system is to form the saline water by purifying saline source water with electro-dialysis reversal or reverse osmosis for gold mining production. It also recycles the waste water and provides a method for growing and harvesting algae utilizing saline water as growth medium to extract the remaining metals out of waste water.

4.0 BRIEF DESCRIPTION OF THE SYSTEM PROCESS FLOW DIAGRAM

Referring to Figure 1, first, the brackish water or the saline water is supplied to a first water purification system 1 that removes, preferably, suspended solids, and/or gases from the brackish water and produces purified water and saline reject water. The brackish water or the saline water may be supplied from various water resources, including, but not limited to, river water, lake water, ocean water, and/or another water purification system. The brackish water has a salinity of, preferably, 0.5 to 30 grams of salt per liter.

The saline water has a salinity of, preferably, 30 to 50 grams of salt per liter. The purified water produced by the first water purification system 1 may have various purity levels to provide water for, for example, human consumption, animal consumption, or agricultural purposes. The purified water is stored in a purified water reservoir 3.

The purified water reservoir 3 is supplied to a gold mining production system 4 for producing gold. Then, the saline reject water is supplied to a second water purification system 2 that further purifies the saline reject water to produce highly saline reject water and purified water. Therefore, the purified water by the first and the second purification systems 1 and 2 may be delivered to the water reservoir 3 or may be gathered in different water reservoirs (not shown in Figure 1).

The highly saline reject water has a preferable salinity of 50-500 grams of salt per liter. Water purification systems as disclosed in this application include, but are not limited to, reverse osmosis, electro-dialysis reversal, and mechanical vapor compression distillation.

The highly saline reject water may be treated in an optional treatment unit 5 before being introduced into a bioreactor containing microalgae 7. Examples of such treatments include, but are not limited to, treatment with UV lamp, heating, or addition of materials to change chemical or physical property.

The additive chamber 6 may include one or more separate containers for storing the materials to be added. Additionally, each of the separate containers may have a separate control valve 13 to control the addition.

The containers comprising the additive chamber 6 may have a separate control valve for each container in the additive chamber 6. The control valve controls the flow rate of addition of additives in the additive chamber 6 to the treatment unit 5. The flow rate may be reduced or increased by the control valve if more or less additives need to be introduced to the treatment unit 5. After passing through the treatment unit 5 the highly saline reject water is sent to a bioreactor containing microalgae 7.

Once the water having adjusted salinity is at a desired salinity level, CO_2 level, pH level, and nutrient level, it may be fed to a plurality of bioreactors 7. The bioreactors 7 may take the form of including but not limited to ponds, preferably covered ponds. The bioreactors 7 may include a combination of a bioreactor and a subsequent pond in combination. Each of the bioreactors 7 houses microalgae, which may be the same or different. Multiple streams of different water salinity are provided for optimum production of algae in each case. The bioreactor 7 may be a batch, a fed batch, or a continuous bioreactor. Preferably the bioreactor 7 is a fed batch bioreactor.

In the algae growing and harvesting chamber 8, the biomass is grown, cultivated, and/or harvested by providing the factors that influence the occurrence, growth, and production yield of algae or biomass. For example, carbon dioxide from a carbon dioxide source 10 and light from a light source 9 at a temperature favoring algae or biomass growth are provided over a period of time. The temperature is in the range of 10 to 80 °C more preferably in the range of 16 to 27 °C.

Algae species that are grown in the bioreactor include but are not limited to Acaryochloris, Amphora, Anabaena, Anacystis, Anikstrodesmis, Botryococcus, Chaetoceros, Chlorella, Chlorococcum, Crocosphaera, Cyanotheca, Cyclotella, Cylindrotheca, Dunaliella, Euglena, Hematococcus, Isochrysis, Lyngbya, Microcystis, Monochrysis, Monoraphidium, Nannochloris, Nannochloropsis, Navicula, Nephrochloris, Nephroselmis, Nitzschia, Nodularia, Nostoc, Oochromonas, Oocystis, Oscillartoria, Pavlova, Phaeodactylum, Platymonas, Pleurochrysis, Porhyra, Prochlorococcus, Pseudoanabaena, Pyramimonas, Selenastrum, Stichococcus, Synechococcus, Synchocystis, Thalassiosira, Thermosynechocystis, and Trichodesmium species.

The Carbon dioxide, as CO_2 gas may be supplied from an industrial source as an additive in the additive chamber 6 and injected into the highly reject saline water in the treatment unit 5 to provide a desirable level of CO_2 in the water for subsequent use in algae growth and/or harvesting in the algae growth and harvesting chamber 8. The CO_2 may be derived through drilling processes during mining operations or other sources.

The remaining waste water which has heavy metals delivered to waste water processing unit 11 that removes, preferably, suspended metals by using algal biomass as filter, and purified water to supply gold mining production system 4. Then, the remaining materials delivered to extract remaining metals unit 12 that removes, preferably, the metals out of algal biomass.

The remaining waste water which has heavy metals is delivered to the waste water processing unit 11. The waste water processing unit 11 removes suspended metals from the stream of concentrated biomass through algal biomass as a filter and purified water that is delivered to the gold mining production system 4. The flow rate of the stream of purified water may be controlled by a control valve 7. The control valve 7 controls the flow rate of addition of the stream of purified water to the gold mining production system 4. The flow rate may be reduced or increased by the control valve 7 if more or less of the stream of purified water needs to be added to the gold mining production system 4.

The gold mining production system separates gold from a gold ore by a method including but not limited to gold cyanidation, CIL circuit process, thiosulfate leaching, or a bulk leach extractable gold process. The gold mining production system 4 uses the stream of purified water and the purified water from the purified water reservoir 3 to separate other metal ions in the gold ore from the gold.

The gold mining production system uses the method of CIL circuit process to separate the gold product from the gold ore. Activated carbon is a highly porous material with distinct adsorptive properties. Gold complexes with either chloride or cyanide are strongly adsorbed by activated carbon. Gold recovery from solution by granular, begins by loading, or adsorbing the gold onto the activated carbon, which is accomplished in the carbon-in-leach (CIL) circuit. The CIL activated carbon system involves adding the carbon to the ore slurry in leaching tanks. The carbon adsorbs the gold from the solution as cyanidation of the ore proceeds.

The gold mining production system 4 uses the algal mat produced from the stream of concentrated biomass to separate the gold product from the gold ore. In one embodiment the algal mat is present in a sluice-type arrangement to separate the gold product from the gold ore. The sluice box comprises riffles that may be coated with algae or algal biomass to capture gold particles as they pass through the sluice-type arrangement. In another embodiment the algal mat comprises a plurality of algal layers in the range of 1-10,000 layers of algae. Preferably the algal mat comprises 10-200 layers of algae. Also, the algal mat may reduce the concentrations of potentially deleterious elements or metals including but not limited to aluminum, iron, manganese, nickel, zinc, and copper from the gold ore by 5- and 10-fold. The algal mat may separate the metals or elements from the gold ore by passing the gold ore through the algal mat. The metals then adhere to individual filaments of the algal mat. The structure of the biomass formed may act as carpeting grown on the riffles in the sluice-type arrangement. The algal mat comprises carbohydrates and proteins from the algae including but not limited to sulfate groups, carboxylate, and sulfhydryl. The positively charged heavy metals including gold from the gold ore bond to the negatively charged ions in the algal mat and the remaining materials from the gold ore pass through the algal mat without bonding to the algal mat. The remaining materials from the gold ore pass to the extract remaining metals unit 12.

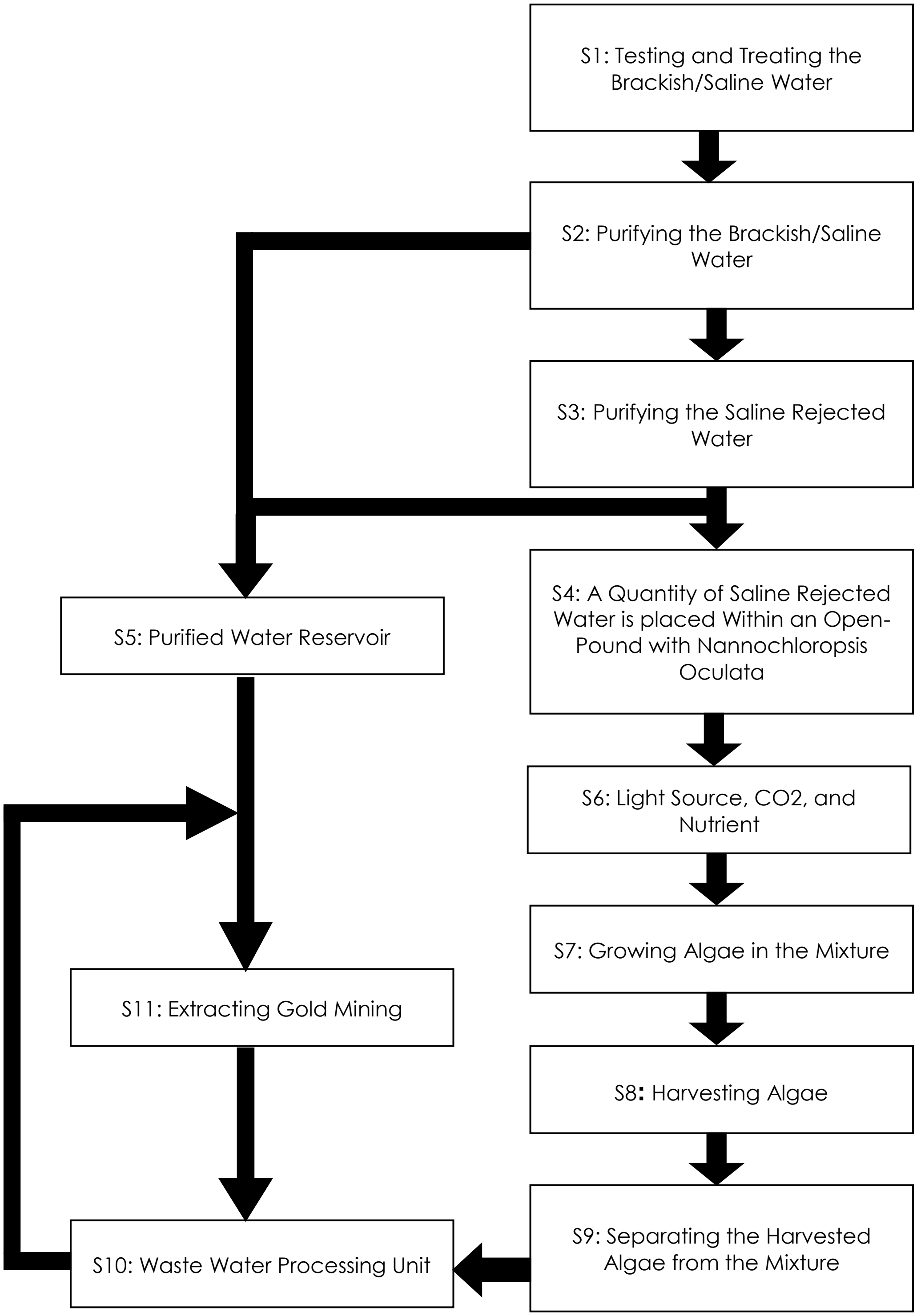

Figure 2 The process for using brackish/Saline water sources for extracting gold mining, growing and harvesting algae

5.0 THE PROCESS FOR EXTRACTING GOLD MINING, GROWING AND HARVESTING ALGAE

The process for using brackish/Saline water sources for extracting gold mining, growing and harvesting algae are shown in Figure 2.

In step S1, the brackish/Saline water is sequestered in a tank where it is tested and treated in order to provide a suitable environment to purify the brackish/ saline water.

In step S2, depending on level of salinity and cost, various methods are utilized for purifying the brackish water, such as reverse osmosis (RO), electro-dialysis reversal (EDR), or similar membrane techniques. Water purification process of brackish water produces purified water and saline reject water as main product and by-product, respectively.

In step S3, the produced saline reject water usually contains a higher concentration of various salts in water compared to the brackish water. A number of subsequent purifications may be performed to extract the remaining purified water from the saline reject water.

In step S4, the saline rejected water and microalgae strain are placed within the photo bioreactor. In step S6, properties of the saline rejected water such as temperature, pH, CO2, nutrient, and/or light exposure are continually monitored and adjusted to allow a suitable environment for algae growth and reproduction.

In step S5, the purified water is stored in a purified water reservoir. The purified water reservoir is supplied to a gold mining production system for producing gold.

In step S7, the microalgae reaches an adequate growth threshold and may be harvested after a period of time. Then, in step S8, the microalgae biomass is harvested from the bioreactor in its growth solution before its separation via centrifugation.

In step S9, the algae are separated from the growth solution. Examples of methods for separation and cultivation include, but are not limited to, centrifuging, filtering, or adding and mixing chemicals that makes a suspension and enables separation of supernatant (that includes remaining salt and nutrient) from the concentrated biomass.

Then, the excess solution water is desalinated as indicated in step S10 and the reject water from that process is utilized for the growing halophytes as indicated in step S9. Reject water may also be devoted to processing the left over solution from the separation phase as indicated in step S10 which contributes to starting the entire cycle over again. Then in step S11, the gold mining production will process.

6.0 CONCLUSION

The proposed system aims to provide a process of Purification system for using saline water, and saline reject water produced in water purification, to use for gold mining production, and growing and harvesting algae too. Also, the proposed system provides an improved method for growing and harvesting algae with the use of saline water as growth medium for recycling waste water in order to extract the remaining metals out of waste water. Furthermore, the harvested algae may be used in various types and different categories of applications including, but not limited to, water purification systems for gold mining production, and extract metals out of remaining waste water.

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