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# A SHORT REVIEW OF PRODUCED WATER MANAGEMENT SYSTEM FOR BENEFICIAL USE

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## ABSTRACT

The produced water (PW), which could be a confounding blend of different natural and inorganic mixes (generally salts, minerals and oils) is a noteworthy wastewater stream formed during petroleum generation forms. With the worldwide interest and production of petroleum derivative (oil and gas) increment, the produced water generation likewise increases similarly. Previously, PW was just re-injected into the unfilled well after extraction. As freshwater deliver turns out to be gradually rare, PW can turn into a significant water source after suitable treatment. There are different physical and substance strategies to treat the PW. Nonetheless, a thorough and thoughtful understanding of each issue can prompt a higher and progressively productive arrangement. In this investigation, different physical and chemical treatment techniques for PW have been checked on dependent on the most recent detections and as of late distributed articles on this topic. Moreover, difficulties and chances of every one of these treatment plans have been completely discussed. In expansion, possible applications for reprocessing the treated PW have been recommended and talked about at long last.

**Keywords:** Produced water**,** Wastewater, Treatment technology, zero discharge.

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## 1. INTRODUCTION

The importance of petroleum products (oil and gas) in present civilization is notable but most production movements, oil and gas production process generate huge amount of liquid waste known as Produced water (PW). PW contains different natural, cations (e.g. Mg, Ca, Ir), anions (e.g. $CO_3^{2-}$ and $SO_4^{2-}$ ) and other substances such as heavy metals (e.g. Br, U, Cr, Pb and Cd) and inorganic components (Fakhru'l-Razi et al., 2009). Discharging produced water can contaminate surface and underground water as well as soil. To meet environment guiding principle just as reuse and reusing of PW, numerous analysts have concentrated on treating oily saline PW. Oil substance and saltiness of PW from offshore and onshore activities can be diminished throughout different physical, chemical and biological techniques. In sea withdrawal facilities, because of space requirements, minimal physical and chemical technologies are preferred (K Dahm & M Chapman, 2014; Drewes et al., 2009). In any case, as capital expense of physical methods and charge of chemicals materials for chemical treatment of unsafe substance is high, the use of these techniques is partial. Existing methods cannot eradicate minute suspended oil and/or risky dissolved organic and inorganic components (K Dahm & M Chapman, 2014) . Otherwise, biological handling is a lucrative method for removing dissolved and suspended mix from oil field wastewater in ground extraction amenities. The main purpouse of this review is to ontroduce the glovbal onshore and offshore production along with avaliable techology to treat the produced water for benificial use or executing environmental rules and regulation.

## 2. GLOBAL PRODUCED WATER PRODUCTION

PW represents the highest amount fluid waste stream for the fuel industry. The worth of managing PW is a noteworthy issue in the profitability of wells and extreme water production is one of the main reasons to abandon an oil or gas well, leaving behind large volumes of hydrocarbons. Published data indicate that the volumes of PW generated worldwide are steadily increasing day by day (e.g. 70 billion barrels in 2007; 100 billion barrels in 2011)(Fakhru'l-Razi et al., 2009; Veil, Puder, Elcock, & Redweik Jr, 2004). It is shown that in 2003, nearly 0.667 billion metric tons (MT) of PW were discharged to the sea area in the planet in which 0.0211 billion MT were discharged to US Gulf of Mexico sea area and between 0. 358 and 0.419 billion MT were discharged to the North Sea of the Europe sea waters (Al-Ghouti, Al-Kaabi, Ashfaq, & Da'na, 2019; Garland, 2005). Worldwide produced water production is projected at around 0.250 billion barrels per day weigh against with around 80 million barrels per day of crude oil. Published statistics from 2007 seem to agree on a worldwide water oil ration (WOR) of 3:1 (Fakhru'l-Razi et al., 2009; Veil et al., 2004) while data from 2011 attributes for onshore crude oil operations in the US a WOR of roughly 8:1 and 12:1 for 2007 and 2025 respectively (*Produced Water Market - Opportunities in the oil, shale and gas sectors in North America*, 2011;Echchelh, Hess, & Sakrabani, 2018) considering water cut 70%.

## 3. PPRODUCED WATER CHEMISTRY

The chemistry of produced water varies with geographic location of the filed production, geological formation, production methods, type of reservoirs, life time of production etc (Veil et al. 2004). Produced water discharge from oil field less toxic than produced water from gas/condensate filed but volume of produced water just reverses (Duraisamy, Beni, & Henni, 2013).

Table 1: produced water properties("The Facts About Instant Ocean®," ; Fakhru'l-Razi et al., 2009; Fillo & Evans, 1990; Igunnu & Chen, 2014; Johnson, Kanagy, Rodgers, & Castle, 2008; "MINERAL MAKEUP OF SEAWATER," ; Shepherd, Shore, Mertens, & Gibson, 1992; "Wastewater discharge standards in Latin America,")

| Parameters (Unit) | Gas field produced water | Oil field produced water | Sea Water Composition | Wastewater discharge standards in Latin America |
|---|---|---|---|---|
| pH | 3.1-7.0 | 4.3-10 | 8.3-8.45 | 5-10 |
| Conductivity (µS/cm) | 4200- 586,000 | 4200 -58600 | | - |
| Alkalinity | 0-285 | - | - | - |
| TDS (mg/L) | 2600-360,000 | - | - | - |
| TSS (mg/L) | 8-5485 | 1.2-1000 | - | 60-600 |
| $BOD_5$ (mg/L) | 75-2870 | - | - | 33-800 |
| COD (mg/L) | 2600-120,000 | >1220 | - | 250-1500 |
| Aluminum (mg/L) | <0.5-83 | 310- 410 | 1.9 | 5-10 |
| Arsenic (mg/L) | <0.005-151 | <0.005–0.3 | 0.024 | 0.5-1.5 |
| Barium (mg/L) | 9.65 -1740 | 1.3 -650 | 0.05 | 0.1-5 |
| Boron (mg/L) | ND -56 | 5–95 | 4.6 | 4-5 |
| Bromide (mg/L) | 150- 1149 | - | 65 | - |
| Cadmium (mg/L) | <0.015- 1.21 | <0.005–0.2 | 0.00011 | 0.1-1.5 |
| Calcium (mg/L) | 9400- 51,300 | 13 -25800 | 400 | - |
| Chloride (mg/L) | 1400- 190,000 | 80–200,000 | 18980 | - |
| Copper (mg/L) | <0.02-5 | <0.02 -1.5 | 0.09 | 1-15 |
| Chromium (mg/L) | ND-0.03 | 0.02 -1.1 | 0.00005 | 0.1-0.75 |
| Iron (mg/L) | 39-1100 | <0.1–100 | 0.02 | 1-25 |
| Lead (mg/L) | <0.2- 10.2 | 0.002–8.8 | 0.005 | 0.5-1.5 |
| Lithium (mg/L) | 18.6- 235 | 3–50 | 0.1 | - |
| Magnesium (mg/L) | 0.9- 4300 | 8–6000 | 1272 | - |
| Manganese (mg/L) | 0.045-63 | <0.004–175 | 0.01 | 1-10 |
| Nickel (mg/L) | <0.08 - 9.2 | - | 0.0005 | 2-6 |
| Potassium (mg/L) | 149 -3870 | 24–4300 | 380 | - |
| Silver (mg/L) | 0.04-7 7 | <0.001- 0.15 | 0.0003 | 0.1-1.5 |
| Sodium(mg/L) | 520-120,000 | 132–97000 | 10561 | - |
| Sulfate (mg/L) | <0.1 -47 | <2 -1650 | | 250-1000 |
| Zinc (mg/L) | <0.02- 5 | 0.01–35 | 0.014 | 3-10 |

| | | | | |
|---|---|---|---|---|
| Strontium (mg/L) | <6200 | 0.02–1000 | 13 | - |
| TOC (mg/L) | 67 -38,00 | 0-1500 | 3 | - |
| Surfactants (mg/L) | 0.08- 1200 | - | - | 5-10 |
| Benzene (mg/L) | <0.010 -10.3 | - | - | - |
| Toluene (mg/L) | <0.010 -18 | - | - | - |
| Oil/grease(mg/L) | 2.3- 60 | - | - | 20-100 |
| Density (kg/m$^3$) | 1014–1140 | 1014–1140 | - | - |
| Total oil (IR; mg/L) | - | 2–565 | - | - |
| Volatile (BTX; mg/L) | - | 0.39–35 | - | - |
| Bicarbonate (mg/L) | - | 77–3990 | - | - |

The major components of produced water are salt, oil and grease, polyaromatic hydrocarbon, organic acid, organic and inorganic compounds etc. The components of produced water (gas filed and oil field) along with sea water and wastewater discharge standards in Latin America shown in **Table 1**.

## 4. PRODUCED WATER DISCHARGE RULES

In petroleum industry, produced water treated conservatively and discharge into the sea at offshore platform or re-inject into the soil in the onto land area. even though the fact it should light certain standard, this causes, soli, surface water, and underground water contamination (Jiménez, Micó, Arnaldos, Medina, & Contreras, 2018). Oil and gas concentration in produced water was the main concern for the government and they imposed policy to dispose the oil and gas contain in produced water but the other component like heavy metal, organic and inorganic compounds discharge from offshore platform are very toxic for the ecosystem and destroy the normal ecology(Jiménez et al., 2018). The worldwide produced water effluent oil concentration limitations showing in **table 2.** But now a days the worldwide petroleum company working toward the implementations of "zero discharge" rules executed by different directivelike EU(Heins & Schooley, 2004; Jiménez et al., 2018; Knudsen et al., 2004) through different treatment technologies.

**Table 2**: Worldwide effluent oil discharge limit (Jiménez et al., 2018; Stewart & Arnold, 2008)

| Sl. | Country/ Region name | Oil concentration limit and Facilities |
|---|---|---|
| 1 | Argentina and Venezuela | 15 mg/ L, New facilities |
| 2 | Brazil, Ecuador, Colombia | 30 mg/ L, All amenities |
| 3 | Indonesia | 25 mg/ L, Grand fathered facilities |
| 4 | Middle East, Malaysia | 30 mg/ L, All amenities |
| 5 | Nigeria, Ivory Coast, Angola, Cameroon | 50 mg/ L, All amenities |
| 6 | Australia , North Sea | 30 mg/ L, All amenities |
| 7 | Thailand | 50 mg/ L, All amenities |
| 8 | USA | 29 mg/ L, OCS water, Zero release inland water |

## 5. PRODUCED WATER MANAGING TECHNOLOGIES

The over-all purposes for machinists treating PW are: removing oil and grase, desalination, deduction of suspended elements and sand, elimination of resolvable organics, exclusion of dissolved gases, elimination of naturally occurring radioactive materials (NORM), disinfection and softening (Arthur, Langhus, & Patel, 2005; Fakhru'l-Razi et al., 2009). Within the avalible varoius technology option , selection of treating option for PW varies according to differnt parameters susch as water properties (chemical & properties), environmental rules and regualtion,volume of produced water, end-use, technical avaliability, economical fesibility (Jiménez et al., 2018). To convene up with this purpose, operators have applied various impartial and joint chemical, physical and biological treatment techniques for PW handling. Among the techniques, widely used methods are illustrated in below section.

### 5.1 Membrane Filtration Technology

Membranes are micro-porous films with explicit pore evaluations, which specifically separate a liquid from its elements. At present most commonly used membranes technologies are Microfiltration (MF), Ultrafiltration (UF), turn around reverse osmosis (RO) and Nanofiltration (NF) (Xu & Drewes, 2006; Igunnu & Chen, 2014).

#### 5.1.1 Microfiltration/Ultrafiltration

Microfiltration (MF) is second oldest pressures driven membrane applications practiced commercially for treating water (Eykamp, 1995) . It can competent of removing µm size substance such as main pathogen, large bacteria, perched particles, proteins and yeast cell based on the separation process (Anis, Hashaikeh, & Hilal, 2019). Microfiltration (MF) has the largest pore measurement (0.1-3 $\mu$m) where Ultrafiltration (UF) pore sizes range from 0.01 to 0.1 $\mu$m *(Drewes et al., 2009).* MF is also classically used for turbidity diminution, deletion of suspended solids, *Giardia,* and Cryptosporidium where UF membranes are used to eliminate germs, color, smell, and some colloidal usual organic matter which operated within ressure ranges 1-30 psi (Commission, 2012; Drewes et al., 2009; Igunnu & Chen, 2014). Main advantage of the technology is , water recovery 90% to 100 % with longer lifespan of ceramic membranes where requirement of the Membrane periodic cleaning and recycling the waste generated during cleaning are the main drawback of this technology (Fakhru'l-Razi et al., 2009).

#### 5.1.2 Reverse Osmosis and Nanofiltration

The working principal (pressure driven) of Reverse osmosis (RO) and nanofiltration (NF) similar as MF and UF. Osmotic power of the flexibly arrangement smothered by applying water powered weight which powers saturate (clean water) to diffuse through a thick, non-permeable layer where seawater RO can reallocate contaminants as little as 0.0001 mm. Present water treatment using RO with appropriate pretreatment much efficient than early initially using RO membranes(Spiegler & Kedem, 1966; Thiruvenkatachari, Su, & Cunnington, 2020). The main cost of a RO plant mainly installation cost which mainly depends on location of the site, rejection required, materials of constructions and operating cost which depends on energy cost and total dissolved solid (TDS) level in the supply water (Al-Ghouti et al., 2019; Mondal & Wickramasinghe, 2008). RO membrane systems regularly have a life expectancy of nearly 3–7 years (Drewes et al., 2009). With advancement of technology forward osmosis and Reverse Osmosis combination are used for higher efficiency (Thiruvenkatachari et al., 2020). NF is a hearty tools for water softening and metals elimination and is designed to eliminate contaminants as small as 0.001 mm (Drewes et al., 2009) .The water water containing TDS in the range of 500–25000 ppm we can use NF to remove the TDS of the water where working procedure similar as RO (Drewes et al., 2009). NF membranes be engaged for PW treatment on both bench and pilot scales (Nicolaisen & Lien, 2003; Al-Ghouti et al., 2019).

### 5. 2 Thermal Technologies

Before the development of membrean technology, thermal treatment technologies for water desalination were popular where the cost of energy was relatively cheap(GWI, 2006). Vapour compression distillation (VCD) , Multistage flash (MSF) distillation and multieffect distillation (MED) are the principal thermal desalination technologies used universal (Watson, Morin, & Henthorne, 2003).Arrangement of MED–VCD technologies known as hybrid thermal desalination plant is much efficient than a single technology(Drewes et al., 2009). Recent technology development makes thermal process extra striking and competitive in treating highly polluted water.

#### 5.2.1 Multistage Flash Distillation

During Multistage flash (MSF) distillation, water switch to steam in a vacuum chamber at low pressure where the boiling peak of water is lesser than at atmospheric pressure and necessitate a lesser amount of energy (Drewes et al., 2009). Several grown-up seawater desalination plants apply the MSF distillation process where its energy necessity is between 3.35 kw to 4.70 kwh to produced 1 bbl fresh water (Darwish, Al Asfour, & Al-Najem, 2003) .

MSF naturally has the maximum water production charge among on hand desalination technologies, which can be abridged with using co-generation or solar energy (Islam, Banat, Baba, & Abuyahya, 2019). Main benefits of this technology are , it require less labor cost than membrane technology and good for suitable for high TDS PW treatment. Other hand water recuperation habitually between 10 to 20 % where scaling and corrosion also difficulty (Drewes et al., 2009; Fakhru'l-Razi et al., 2009).

**5.2.2 Vapor Compression**

The provided water is heated in a heat exchanger by the product and rejects streams from the system during vapor compression (VC) process. Most common vapore comression are themal valor compresson (TVC) and Mechanical vapor compression (MVC) where Mechanical vapor compression (MVC) desalination is one of the mostly efficient wide-reaching used thermal distillation processes (Bahar, Hawlader, & Woei, 2004; El-Dessouky, Ettouney, & Al-Juwayhel, 2000). The thermal performance ratio of the TVC system decrease with increase the temperature for top brain while the specific power consumption of the MVC systems decreases with swelling the temperature. (El-Dessouky et al., 2000). The MVC technology require more electrical energy (7-10 Khw/$m^3$ ) than MSF technology ( 3-4) Khw/$m^3$ but the capital cost are much more higher for MSF installation (Bhojwani, Topolski, Mukherjee, Sengupta, & El-Halwagi, 2019).

**5.2.3 Multieffect Distillation**

Multieffect Distillation (MED), converts briny water to steam, which is condensed and recovered as fresh water necessitates adequate energy. The main advantage of the technique is the energy effectiveness gained through the assemblage of various evaporator techniques where fresh water upturn inside 20 to 67 % depending on the category of the evaporator plan engaged (Katharine Dahm & Michelle Chapman, 2014; Watson et al., 2003) . It is good for treat high TDS contain produced water (Rostamzadeh, Ghiasirad, Amidpour, & Amidpour, 2020). MSF can to be used extensively due to scaling problem which can be decrease by using, falling film evaporators (Katharine Dahm & Michelle Chapman, 2014). Scale inhibitors and linked chemicals may be requisite to avoid scaling and pH control is important to avoid corrosion (Drewes et al., 2009). The energy cost for this technology ranges 1.3–1.9 kWh/bbl (Darwish et al., 2003) where operating cost and entire unit cost are $0.11/bbl and is $0.16/bbl respectively (Ettouney, El-Dessouky, Faibish, & Gowin, 2002).

**5.2 Biological Aerated Filters**

Biological aerated filter (BAF) which consists of porous media that uses aerobic conditions to assist biochemical oxidation and removal of organic constituents in polluted water (Fu, Wu, Zhou, Zuo, & Ding, 2016). Maximum satisfactory diameter of the media is 4 in to prevent clogging of pore spaces when sloughing occur (Watson et al., 2003). BAF can eradicate oil, suspended solids, ammonia, nitrogen, heavy metals, chemical oxygen demand (COD),), iron, soluble organics, trace organics , ammonia, biological oxygen demand (BOD ) and hydrogen supplied from produced water (Drewes et al., 2009; Marsidi, Hasan, & Abdullah, 2018; Watson et al., 2003). This technology needs upstream and downstream sedimentation to permit the complete bed of the filter to be used. . This process can remove 70% nitrogen, 80% oil, 60% COD, 95% BOD and 85% suspended from the mixture solids (Bradley, 1990; Drewes et al., 2009).

**5.3 Hydrocyclones**

Worldly used physical method Hydrocyclones, use to separate solids components from wastewater based on density variations. metals, plastics or ceramic, and generally have a cylindrical top and a narrowed base with no moving components are used to build the hydrocyclone where its performance determined by the angle of its conical section (Drewes et al., 2009) . Total habitation time in the hydrocyclone is not more than 2-3 seconds (Bradley, 1990). Hydrocyclones are used along with other technologies as a pre-treatment methods which can remove patricles in the range of 5-15 μm (Drewes et al., 2009). The technologies has a long lifetime and do not necessitate the pre-treatment of feed water but main drawback of this method is the generation of vast slurry of intense solid waste (Niazi, Habibian, & Rahimi, 2017).

**5.5 Flotation Separation**

Gas flotation components work by introducing tiny gas bubbles within the wastewater being treated. The gas bubbles obtain a tiny electronic charge; turn around that of the oil droplets. During gas bubbles rise through the fatty wastewater, oil put together to the bubbles (Igunnu & Chen, 2014; Stewart & Arnold, 2008). Flotation units make use of two separate techniques for producing tiny gas/air bubbles required to contact with water: pressurized gas/air inoculation and induced gas/air (Cline, 2000). In Flotation separation process , water recover almost 100% without pre-treatment are the main advantages where main limitation is it's not applicable for high temperature feed water (Igunnu & Chen, 2014).

**5.6 Evaporation Pond**

Evaporation pond is an artificial pond have been used over the centuries to get rid of water from saline solution that needs a comparatively huge space (Ahmed et al., 2000). They are planned either to prevent subsurface intrusion of water or the downward moving of water depending on produced water class (Consulting, 2003). Evaporation ponds can be efficiently used as a dumping technique specially in countries with dry and warm weather, high disappearance rates, and ease of use of land at low cost. Several scholars have explored ways to increase evaporation rates (Hoque, Alexander, & Gurian, 2010).The major advantages for dumping of brain using evaporation ponds are, evaporation ponds are comparatively easy to construct, while requiring minimum maintenance and little operator attention weigh against to mechanical arrangements excluding the pump that put across the wastewater to the pond (Velmurugan & Srithar, 2008). The main difficulties of the system are it required huge land and may create environmental disaster if accident occur or leakages in the pond (Ahmed et al., 2000; Consulting, 2003).

**5.7 Adsorption**

Adsorption, most commonly and inexpensive used methods for produced water treatment which can remove 80 % of heavy meatls and water recovery nearly 100 percent(Ali & Gupta, 2006; Katharine Dahm & Michelle Chapman, 2014; Shen et al., 2019).Adsorbeing materials like zeolites, activated alumina, activated carbon and organo clays which can eradicate iron, manganese, TOC, and other contaminants by using minimal chemicals (K Dahm & M Chapman, 2014; Drewes et al., 2009). The main limitations of this technology is media may require regular substitute or regeneration depending on category and feed water quality (Consulting, 2003).

**5.8 Ion Exchange Technology**

The procedure of ion exchange is a reversible chemical reaction which engages exchange of ion from a solution to similarly charged ion attached to an immobile solid. The process successfully removes arsenic, heavy metals ,nitrates, radium, uranium, and salts from PW (Arthur et al., 2005; Mohammed, Habeeb, Kreamid, & Ali, 2018). Ion exchange resins (IER) are used to get fresh water from low-salinity water sources (Subban & Gadgil, 2019) where chemical require for resin regenerations and disinfection . The working cost accounts for more than 70% of the on the whole cost of this technology (Drewes et al., 2009; Fakhru'l-Razi et al., 2009). The main advantage of this process are it require minimal supervisory oversight and energy wthin continous 10-20 hours operations with fouling limitation.

**5.9 Chemical Oxidation**

Chemical oxidation is a renowned and consistent technology for the subtraction of odor, color, BOD, COD, organics and some inorganic amalgam s from PW (Mendonça, de Araujo, Chiavone, & da Motta, 2017; Veil et al., 2004). Oxidants regularly used consist of $O_3$, R−O−O−R, permanganate, $O_2$ and Cl and the oxidant along with contaminants and causes them to break. The efficiency of the method various on type of the oxidant used, chemical amount, water quality and the point in time among oxidants and water (Drewes et al., 2009; Hassan & Al-zobai, 2019). High chemical cost and energy consumption cost (18% of operation and maintenance cost) are remarkable in this process. No pre and post treatment of water need in this process and necessitate minimal equipment with high expectancy life (10 year or more) (Katharine Dahm & Michelle Chapman, 2014; Jiménez et al., 2018).

**5.10 Electrodialysis (ED)/Electrodialysis Reversal (EDR)**

Electrodialysis (ED) and advancement of ED like Electrodialysis Reversal (EDR), electrochemical-charge-driven separation processes being used for salt water and brackish water desalination and wastewater recuperation (Meller, 1984; Sirivedhin, McCue, & Dallbauman, 2004). In this technology softened ions are estranged from water through ion permeable membranes under the pressure of an electrical potential gradient where the membranes are not as disposed to degradation by chlorine and can treat surface and wastewaters that have high concentrations of organic materials and microorganisms without momentous fouling (Gabarrón et al., 2016). ED/EDR have inadequate ability to eliminate non-charged constituents, including organic molecules, silica, and boron other hand a high level of trained working force is also required to operate ED/EDR systems (Al-Amshawee et al., 2020; Godshall, 2006; Zhao et al., 2019).

**5.11 Freeze-Thaw/Evaporation (FTE®)**

Freeze-Thaw/Evaporation (FTE®) technology developed by BC Technologies and Crystal Solutions company for desalination or treat produced water in 1990 (Boysen & Boysen, 2007). In this development, when the open-air temperature is not as much of 0 °C, the water to be treat is sprayed or dripped onto a freezing pad, shaping a bulky pile of ice (Fakhru'l-Razi et al., 2009; Hasan, 2018).This system develops the fact that salty water has a minimum freezing point than fresh water; so, at temperatures cooler than 0 °C, the excess from the ice pile will be salty brine and when the temperature is such that melting occurs, the runoff will be pure water (FTE® Process for Water Treatment ; Razaghiyan, Rahimi, & Karimi, 2020). The cycle is easy to work and screen, and has a future of 20 years yet it can just working a kind of climate that has generous number of days with temperatures beneath freezing and ordinarily requires a lot of ground (K Dahm & M Chapman, 2014; Drewes et al., 2009). Otherhand waste discarding is crucial when using FTE system because it produces a significant quantity of concentrated brine and oil.

**5.12 Dewvaporation: Altelarain$^{sm}$ Process**

A new technology for desalination of seawater and brine water known as Dewvaporation which is based on the principal of humidification and dehumidification using carrier gas with retrieval of the heat from condensing and dehumidification(Zhu et al., 2006). This process decreases the energy by using counter-current heat exchange machinery (Godshall, 2006). In this system, feed water is evaporated by heated air, which condenses as fresh water on the reverse side of a heat transfer wall. The energy required for evaporation is partly supplied by the energy released during condensation (Drewes et al., 2009). Heat supplies can be combustible fuel, solar, or low-grade heat from a variety of resources.

A US well-known company named Altela Inc. has designed, manufactured, and tested several AltelaRainSM trial product systems based on the dewvaporation process. The company installed three full-scale AltelaRainSM ARS-4000 systems at natural gas wells in the San Juan Basin near Farmington, NM (Igunnu & Chen, 2014) which system can process roughly 4,000 gallons per day (100 bbl/day) of produced water with salt concentrations higher than 60,000 mg/L TDS (Godshall, 2006) . High removal rates of organics, radionuclide and heavy metals from produced water have also been testified for this process (Calderon Carrillo, Aranguren Campos, & Usuriaga Torres, 2017; Godshall, 2006).The main advantages of this process are its required low capital cost and maintenance cost is minimal and treated water quality high(Hasan, 2018).

**5.13 Macro-Porous Polymer Extraction Technology**

A highly efficient technology, Macro Porous Polymer Extraction (MPPE) which is completely robotic, remote controlled and surefire technology for removing dissolved and dispersed hydrocarbons from water with efficiencies of ~100% (Akzo Nobel, 2004; Macro Porous Polymer Extraction (MPPE) Technology). The MPPE act as transporter for nontoxic and eco-friendly removal medium that absorbs and removes hydrocarbons from wastewater. The miniscule plastic spheres can decrease pollutant concentrations in water by a factor of more than 1 million, which means that concentrations of thousands ppm (parts per million) can be lower to below 1 ppb (parts per billion) which is done in only one round ( Pars & Meijer, 1998). Away from clean water for recycling or releasing, the water purification unit also yields almost 100% pure hydrocarbons suitable for use again [Akzo Nobel 2004; Pars, & Meijer 1998, Al-Ghouti et al. 2019).

## 6. DISCUSSION

All states handling techniques have their individual pros and cons. high actual capital costs and sensitivity to the feed stream class are the mainly important complexities of physical technique; whereas unsafe sludge production, high working expenses and sensitivity to the initial concentration of effluents in feed stream are drawbacks of chemical methods. Besides, fouling/scaling concerns and high component price are the weakness of membrane-based treatment techniques. In addition, in offshore production plants, space boundaries support the engineers to use compacted treatment procedures, where as in onto land production units, where enough space is obtainable, a wider variety of treatment methods can be used. Technology alternatives for high-TDS waters for non-industrial uses necessitate a multi-stage process. Theoretical process plan necessitates further methodical work to expand priority technology grouping. **Table 3** represents a common overview of treatment technologies which apply at the present time for PW treatment.

## 7. CONCLUSION

PW management poses the greatest waste stream dealing with challenge confronting the oil business general. The gigantic volumes of PW produced every year from oil and gas exploration and production require savvy, productive and earth lovely strategies for treatment. This activity has tinted a variety of advantages and limitations of technologies and

**Table 3: Overview of treatment technologies which apply nowadays for PW treatment**

| Technology \ Elements | Free oil | Other oil | Particles | Fe & Mn | Ca & Mg | TDS, NaCl | Heavy Metals | Silica | Soluble organics | $H_2S$ |
|---|---|---|---|---|---|---|---|---|---|---|
| MF, UF | | ♠ | ♠ | ♠ | | | ♠ | | | |
| RO-NF | | | ♠ | ♠ | ♠ | ♠ | ♠ | ♠ | ♠ | ♠ |
| Thermal technologies | ♠ | ♠ | ♠ | ♠ | ♠ | ♠ | ♠ | ♠ | ♠ | ♠ |
| Biological aerated filters | ♠ | ♠ | ♠ | ♠ | ♠ | ♠ | ♠ | ♠ | ♠ | ♠ |
| Hydrocyclones | ♠ | | ♠ | ♠ | ♠ | | ♠ | ♠ | ♠ | |
| Gas Flotation | ♠ | | ♠ | ♠ | | | ♠ | ♠ | ♠ | |
| Adsorption(Foam) | ♠ | ♠ | ♠ | ♠ | | | ♠ | ♠ | ♠ | ♠ |
| Ion Exchange | | | | ♠ | ♠ | ♠ | ♠ | ♠ | | |
| Chemical oxidation | | | | ♠ | | | ♠ | | ♠ | ♠ |
| Electro-dialysis (ED)/Electro-dialysis reversal (EDR) | | | | ♠ | ♠ | ♠ | ♠ | | | |
| Freeze thaw evaporation (FTE®) | | | | | ♠ | ♠ | ♠ | | ♠ | ♠ |
| Dewvaporation: AltelaRain$^{SM}$ | | | | | | ♠ | ♠ | | ♠ | |
| Macro-porous polymer extraction (MPPE) | ♠ | ♠ | | | | ♠ | ♠ | | ♠ | |

♠ (sign) means applicable to remove the particles

procedures for PW treatment; with evaluations made among conventional handling methods as well as other techniques. The methods selection significantly influenced by site conditions, composition of PW and local environmental rules and regulations. However, categorization of the PW to determine main components is usually the first step to select most favorable treatment option for use. The result of such characterization will conclude if pre-treatment is necessary, if thermal treatment is compulsory, if chemical dosing could be avoided etc. Therefore, characteristics of the produced water together with ecological factors, economic concerns, and local authoritarian frame work are used to pick the best possible option for treatment of PW in an sea area oil and gas explorationa as well for onshore PW treatment.

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