Petroleum Industries:

Produced Water Effects, Management and Treatment Technologies

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DOI: 10.29322/IJSRP.10.03.2020.p9923
http://dx.doi.org/10.29322/IJSRP.10.03.2020.p9923

Abstract- When hydrocarbons are produced, the well flow typically consists of water produced in affiliation with these hydrocarbons. Oil field produced water is a complex combination of dissolved and particulate organic and inorganic chemical compounds in water that ranges from essentially freshwater to concentrated saline brine. Produced water from oil fields has raise a lot of environmental considers, with the rise of an environmental protection and safety movement, the petroleum companies have positioned higher emphasis on minimizing environmental impact of its operations. The main objectives of oil and gas produced water treatment include meeting discharge standards, reusing treated produced water in oil and gas operations, developing agricultural water uses, cattle and animal drinking water, water for human consumption, and meeting water quality requirements for miscellaneous recommended uses. This article reviews effects of produced water on the environment and technologies for the management of produced water in oil fields.

Index Terms- Produced Water, Oil and Gas, Hydrocarbon, Chemical Oxygen Demand and Treatment Technology.

I. INTRODUCTION

Produced water regularly is produced during the generation of oil and gas from coastal and seaward wells [1]. produced water results from two procedures in the oil and gas industry. To begin with, during extraction, this gives a blend of water and oil; the wellspring of which is typically seawater encompassing the oil well. Second, the water infused into the oilfield to carry the profound oil to the surface likewise eventually turns out to be a piece of delivered water or wastewater [2]. Oil wastewater from processing plants contains significant levels of poisons and is portrayed by the nearness of huge amounts of treatment facility gushing, for example, oil items and synthetic substances that are difficult to corrupt. Administrative specialists deny grants to release this oil wastewater to keep up the compound, physical and organic trustworthiness of the new water assets [3]. Oil field administrators are especially keen on creating unrefined petroleum yet should figure out how to deal with the "essential abhorrence" (delivered water) that accompanies it so as to guarantee proficiency in their tasks. Because of this reality confronting oil field administrators, such a large number of research works have been done to figure out how to deal with delivered water the world over. Release particulars are the admissible emanating points of confinement of constituents of delivered water [4]. The constituents of petroleum water are portrayed as follows: disintegrated and scattered oil mixes, broke down, scattered and suspended natural mixes, treatment synthetic substances (erosion inhibitors, mud cuttings and so forth.), delivered solids, microbes, and metals. Effluent limits are portrayed as follows: PH, temperature, oil/oil content, saltiness, turbidity, complete disintegrated solids (TDS), all out suspended (TSS), compound oxygen request (COD), biochemical oxygen request (BOD), lead, iron, copper, chromium, Zinc, sulfide, sulfate, mercury and turbidity. As far as possible can be resolved in the laboratory [5]. Currently, oil and gas administrators treat produced water through at least one of the accompanying alternatives: Evade generation of water: water breaks are obstructed by polymer gel or downhole water separators, yet this choice isn't constantly conceivable. Infuse into developments: delivered water might be infused back to its arrangement or into different developments. This alternative regularly requires transportation of water, and treatment to decrease fouling and bacterial development. In the long haul, the put away created water may contaminate the underground waters. Release to nature: delivered water might be released to the earth as long as it meets inland and seaward release guidelines, reuse in petroleum industry operations: minimally treated produced water may be used for drilling and workover operations within the petroleum industry. Apply in beneficial uses: produced water may be consumed for irrigation, wildlife consumption and habitat, industrial water and even drinking water. However, beneficial uses of produced water may involve significant treatment. [5]

1. What is produced water

Oil wastewater is the biggest waste stream created in oil and gas enterprises. It is a blend of various natural and inorganic mixes. Because of the expanding volume of waste everywhere throughout the world in the ebb and flow decade, the result and impact of releasing produced water on the earth has of late become a huge issue of ecological concern. Delivered water is expectedly treated through various physical, compound, and organic strategies. In seaward stages on account of room imperatives, reduced physical and compound frameworks are used [6]. Regular

water or arrangement water is constantly discovered together with oil in supplies. It is marginally acidic and sits beneath the hydrocarbons in permeable store media .Extraction of oil and gas prompts a decrease in repository pressure, and extra water is normally infused into the supply water layer to keep up water driven weight and improve oil recuperation [5]. Notwithstanding infused water, there can be water leap forward from outside the store region, and as oil and gas generation proceeds, the opportunity arrives when arrangement water arrives at creation well, and generation of water starts nearby the hydrocarbons. This water is known as delivered water or oilfield saline solution, representing the biggest volume of side-effect created during oil and gas recuperation tasks [7]. It is a mixture of injected water, formation water, hydrocarbons and treating chemicals

1.1. Characteristics of produced water

Produced water contains various substances, notwithstanding hydrocarbons, that influence the way where the water is dealt with. The organization and grouping of substances may fluctuate among fields and even between various generation zones inside a solitary field. The phrasing utilized for focus is milligrams per liter (mg/l), which is mass per volume proportion and is around equivalent to parts per million (ppm). A portion of the significant delivered water constituents are examined in this section [8]. Produced water is definitely not a solitary item, it has an easy to complex organization that is variable, and it is considered as a blend of broke up and particulate natural and inorganic synthetic compounds. Substance and physical properties of delivered water differ significantly which relies upon a few components including, geographic area of the field, age and profundity of the land development, hydrocarbon-bearing arrangement geochemistry, extraction strategy, sort of the created hydrocarbon, just as its compound organization in the store. The poisonous quality of delivered water released from gas stages is multiple times higher than the harmfulness of the oil wells discharge [2]. The primary parts found in produced water are arranged and abridged alongside their focuses from the writing. The significant constituents that are available in created water include: salt substance (estimated as saltiness), all out broke down solids (TDS) or electrical conductivity; oil and oil (O&G); polyaromatic hydrocarbons (PAHs), benzene, toluene, ethylbenzene, and xylenes (BTEX), phenols, natural acids, characteristic natural and inorganic exacerbates that cause hardness and scaling (e.g., calcium, magnesium, sulfates, and barium); and compound added substances, for example, biocides and consumption inhibitors that are utilized during penetrating, breaking and working procedure of the well

Parameter	**Value range**
pH	8.3–8.9
Conductivity (ms/cm)	5.2–6.8
Total suspended solid (mg/l)	30–40
Total dissolved solid (mg/l)	3800–6200
SO4 (mg/l)	14.5–16
COD (mg/l)	3600–5300
Total phenol (mg/l)	160–185
Phenol (mg/l)	11–14
o-cresol (mg/l)	14–16.5
m, *p*-cresol (mg/l)	72–75
N-hexane (mg/l)	1.8–1.85
2,4- and 2,5-DCP (mg/l)	28–32

Table 1. Main characteristics of petroleum refinery wastewater (adapted from[9]).

Table 2. ***Contaminants in raw water (adopted from [10])***

Contaminant	**Problem**	**Removal methods**
Turbidity	Makes water cloudy and deposits in water lines and	Coagulation, settling and filtration
	process equipment	
Hardness	Primary source of scale formation in heat exchangers	Softening, distillation, surfactants
	and pipe lines	
Alkalinity	Causes foaming in steam systems and attacks boiler	Lime and lime-soda softening, Zeolite softening,
	steel. Bicarbonate and carbonate produce carbon	Dealkalization by anion exchange
	dioxide in steam which is highly corrosive	

Sulphate	Adds to the solids content of water and combines with	Demineralization, distillation
	calcium to form calcium sulfate scale	
Chloride	Adds to solids content and increases the corrosive	Demineralization, distillation, desalination (if sea
	properties of water	water is being used)
Silica	Scaling on heating and cooling equipment and	Anion exchange resins, distillation
	Pipelines	
Iron and magnesium	Discolors the water and precipitates in water lines	Aeration, coagulation and filtration, lime softening,
	and process equipment	cation exchange
Oil	Source of scale, sludge and foaming in boilers.	Oil/water separators strainers. coagulation and
	Impedes heat exchange. Undesirable in most	filtration. Diatomaceous earth filtration
	Processes	
Oxygen	Corrosion of water lines heat exchange equipment,	Deaeration, sodium sulphite, corrosion inhibitors
	boilers, return lines, etc.	
Hydrogen sulphide	Cause of 'rotten egg' odor. Corrosion, toxicity	Aeration, chlorination, highly basic anion exchange
Conductivity	Conductivity is the result of ionizable solids in	Processes which decrease dissolved solids content will
	solution. High conductivity can increase the corrosive	decrease conductivity. Examples are demineralization,
	characteristics of a water	lime softening
Dissolved solids	'Dissolved solids' is the measure of total amount of	Various softening process, such as lime softening and
	dissolved material. High concentrations of dissolved	cation exchange by zeolite, will reduce dissolved
	solids are objectionable because of process	solids. Demineralization, distillation
	interference and as a cause of foaming in boilers	
Suspended solids	'Suspended solids' is the measure of undissolved matter.	Sedimentation. Filtration, usually preceded by coagulation and settling
	matter. Suspended solid plug lines, cause deposits in	coagulation and settling
	heat exchange equipment, boilers, etc.	

1.1.1. Salinity

One of the undesirable segments of penetrating liquid at transfer time is salts, similar to sodium or potassium chloride, are frequently added to boring liquid to shield delicate arrangements from responding with the boring liquid. Salt (sodium chloride) in low focuses is basic to the soundness of plants and creatures. At focuses not quite the same as the normally happening levels found in a given environment, in any case, salt can cause an antagonistic effect [11]. Natural impact of created water salts can happen in all districts where oil and gas have been delivered It is as a significant patron of danger [6].

1.1.2. Inorganic Ions

Chloride and sodium are considered as the most abundant salt ions found in produced w ater, while phosphate has the lowest concentration. In produced water from both conventional and unconventional wells; sodium is considered as the dominant cation with 81% in conventional wells and more that 90% in unconventional wells [2]. In addition, sodium, chloride, magnesium, sulfate, bromide, potassium, iodide and bicarbonate are found in produced water with high salinity. The presence of sulfate and sulfide ions in produced water can leads to insoluble sulfate and sulfide at high concentrations in produced water. Moreover, the presence of bacteria in the anoxic produced water, cause the reduction of sulfate and in turn leads to the presence of sulfides (polysulfide and hydrogen sulfide) in the produced water However, the concentration of these anions and cations varies from location and their ranges are presented in the table above.

1.1.3. Heavy Metals

Heavy metals can enter into drilling fluids in two ways: (1) many metals take place naturally in most formations and will be included into the fluid in the course of drilling. (2) additionally metals are introduced to the drilling fluid as phase of the additives used to alter the fluid properties [11]. Heavy steel concentrations in produced water depend on age of the wells and formation geology two Produced water incorporates hint quantities of a variety of heavy metals such as cadmium, chromium, copper, lead, mercury, nickel, silver, Heavy steel concentrations in produced water are typically greater than these of receiving water (for better oil recovery) and these located in sea water [5] . Mostly , mercury, zinc, barium, manganese, and iron are observed in produced water at greater awareness than the seawater attention .However, variations in the type, concentration, and chemical content of the metals are influenced with the aid of the geological age and features, injected water extent and chemical composition [2].

1.1.4. Total Dissolved solids (TDS)

Oil wastewaters include dissolved solids, but the amount varies from less than 100 mg/l to over 300,000 mg/l, relying on the geographical location as well as the age and type of reservoir. In general, water produced with gasoline is condensed water vapor with few dissolved solids and will be clean with a very low salinity. Aquifer water produced with fuel or oil will be a good deal greater in dissolved solids. Produced water from hot reservoirs tends to have greater TDS concentrations while cooler reservoirs have a tendency to have lower ranges of TDS [8]. The conductivity of produced water can differ widely as it was once discovered that the conductivity of produced water from natural gasoline ranged from 4200 to 180,000 μS/cm [2]. produced water is normally characterized as brackish groundwater with elevated concentrations of whole dissolved solids. The inorganic elements present in produced water are in particular derived from the rock formations with which the water is in contact; therefore, the water satisfactory involving inorganic materials is prepared and presented through geologic basin. Water from traditional oil and gasoline can showcase a vast range of TDS concentrations; 1,000 mg/L to over 400,000 mg/L.[12].

1.1.5. Biochemical Oxygen Demand (BOD)

Biochemical Oxygen Demand is the amount of oxygen required by aerobic microorganisms to decompose the organic matter in a sample of produced water. The BOD of 75–2870 mg/l has been reported for produced water from natural gas field Reduced inorganic elements such as Fe and Mn, used fluids for well drilling, and additive chemicals can result in higher BOD concentrations in produced water obtained directly from the well [2] . Furthermore, dissolved oxygen can be use up in water bodies receiving produced water with excessive BOD content, because the microorganisms can only utilize the oxygen initially available thus, substantial oxidation of this water should be ensured to prevent the discharge of waste water with high BOD into natural waters [13].

1.1.6. Chemical Oxygen Demand (COD)

The chemical oxygen demand (COD) represents the amount of chemically digestible organics.

COD measures all organics that have been biochemically digestible as well as all the organics that can be digested through heat and sulfuric acid [13]. COD often is used as a measurement of pollutants in wastewater and natural waters, petroleum wastewater COD measure of the capacity of water to consume oxygen at some point of the decomposition of natural count and oxidation of inorganic chemicals such as ammonia and nitrate [2].

1.1.7. Oil and grease

Oil and grease are the ingredients of produced water that get hold of the most attention in each onshore and offshore operations [14]. The attention of Oil & Gas two in natural gas, produced water range between 6–60 mg/l [2]. Moreover, another find out about used to be carried out on western United States' produced water and the attention of O&G was once discovered to be 40 mg/l to as excessive as 2000 mg/L [12].

1.1.8. Benzene, toluene, ethyl benzene, and xylene (BTEX)

Oil is a mixture of hydrocarbons such as benzene, toluene, ethylbenzene, and xylenes (BTEX), naphthalene, phenanthrene, dibenzothiophene (NPD), polyaromatic hydrocarbons (PAHs) and phenols. Water can't dissolve all hydrocarbons, so most of the oil is dispersed in water [6]. BTEX are volatile fragrant compounds that are naturally existing in oil and fuel merchandise which includes herbal gas, gasoline, and diesel fuel, for that reason they without problems get away to the ecosystem at some stage in the water cure process. two [2].

1.1.9. Phenols

Concentrations of total phenols in produced water commonly are less than 20 mg/L [1]. Phenols or phenolics are section of fragrant natural compounds that include one or more hydroxyl team connected to an aromatic hydrocarbon group. Various tiers of phenols are existing in produced water from oil and gas-operating wells; however, fuel condensate manufacturing was once located to have the best possible awareness of phenols [2]. The comparison of the attention of phenol in produced water from oil and gasoline subject printed that fuel field-produced water has greater concentrations of phenol than oil field-produced water.

1.1.10. Production chemicals

Production chemicals can be pure compounds or compounds containing lively substances dissolved in a solvent or a co-solvent, and used for inhibition of corrosion, hydrate formation, scale deposition, foam production, wax deposition, bacterial growth, fuel dehydration and emulsion breaking in order to improve the separation of oil and water [5]. In addition Production chemicals are normally delivered to the oil or fuel field for the management of the operational troubles such as to facilitate oil, gas, and water separation process, prevention of pipeline corrosion and methane hydrate formation in the fuel production system [2].

II. USE OF PRODUCED WASTEWATER FOR THE OIL FIELD

Although produced water from oil and gas wells normally is considered a high volume, high salinity waste stream, produced water has the attainable to be used to offset water demands and

over allocation of water supplies. Waste circulate administration is necessary to proceed hydrocarbon production from oil and gas well [15]. Recycled/treated PW should be used for underground injection to enhance oil restoration (it is to be noted that PW cannot be injected to the gasoline reservoirs), use for irrigation, wildlife watering, and various industrial purposes such as dust manipulate (specially in Middle East region), automobile washing, cooling water make-up and fire-fighting systems [16]. Since the demand and production of oil and gas is continuing to make bigger globally, the environmental footprints associated with this production are increasing, such as produced water. Furthermore, as the scarcity of freshwater furnish is increasing, produced water can be a indispensable source of water after appropriate remedy [2]. There has been an increased attention on reclaiming, reusing, and recycling of water that is commonly wasted to meet the communities' needs of freshwater source. Different standards for reuse of dealt with water have been provided based on meant purpose. As expected, the standards for ingesting water are more stringent and therefore, more great therapy of produced water is needed. There are quite a few picks for utilization of produced water such as consuming water, irrigation, livestock watering, habitat and wildlife watering, hearth control, and industrial makes use of such as dust control, oil subject uses, and power generation. Based on the traits of produced water mentioned previously, cure of the produced water is required to meet the quality standards before re-using it.

Table. 1 *Standards for water reuse for drinking, irrigation and livestock purposes*

Component	Drinking (g/m3)	Irrigation (g/m3)	Livestock (g/m3)
Li^+	-	2500	-
K^+	-	-	-
Na^+	200	Based on SAR	2000
NH3	1.5	-	-
$Ca2^+$	-	Based on SAR	-
$Mg2^+$	-	Based on SAR	2000
Cl^-	-	-	-
Br^-	250	-	1500
HCO3	-	-	-
SO4	250	-	1500
TDS	500	2000	5000
Conductivity	-	2.5	1.5-5
Sodium adsorption ratio (SAR)	-	0-6	-

1.2. Livestock watering

Water quality consumed by farm animals normally have decrease requirements than the quality of water for human consumption as the contaminant tolerance of livestock is higher than humans. However, contaminants existing in the water used by way of animals need to be underneath sure restriction to keep away from negatively affecting their health [2]. Livestock can tolerate a range of contaminants in their drinking water. At some concentrations, the animals, even though nevertheless capable to survive, will commence to show some impairment [14]. For instance, water with<1000 mg/l of TDS can be used as a water source for livestock. it can affect the fitness of farm animals by inflicting diarrhea if the fee exceeds 7000 mg/l. This notion was once utilized in some projects CBM in which they hooked up watering stations for cattle to make use of produce water as drinking water [14].

1.3. Habitat and wildlife watering

Produced water can be used after semi-intensive remedy and making sure its innocent nature to create artificial reservoir for providing consuming water source for flora and fauna as well as imparting habitat for waterfowl and fishes [2]. Some Rocky Mountain place CBM tasks have created impoundments that collect and continue massive volumes of produced water. In some cases, these can also have floor areas of at least numerous acres. These impoundments furnish a supply of consuming water for natural world and offer habitat for fish and waterfowl in an in any other case arid environment. It is important to make certain that the first-rate of the impounded water will no longer create health issues for the wildlife [14].

1.4. Irrigation

Produced water, then again after treatment, should be used for agricultural issues, for livestock and animal watering. Such applications are realistic benefits, specifically for arid regions. However, in such case, a suitable cure technological know-how is essential [16]. Reuse of produced water for irrigation specifically in dry lands has been endorsed and reviewed the essential challenges consist of sodality, salinity, unique ion toxicity, and alkalinity which are magnified because of the decrease produced water quality; therefore, it is very crucial to consider the crop type when using produced water for irrigation [17]. After the cure of produced water and removal of all pollutants, if the quality of handled water is assembly with sure requirements and having low enough TDS, we can consider produced water as a precious useful resource for irrigation of crops [2]. Many components of the United States and round the world have limited freshwater resources. Crop irrigation is the largest single use of freshwater in the United States, making up 39% of all freshwater withdrawn, or a hundred and fifty billion gallons per day (USGS 1998). If produced water has low adequate TDS and other characteristics, it can be a treasured aid for crop irrigation [14].

1.5. Industrial uses

The treated Produced water ought to be reused in drilling and/or EOR programs. This can minimize the clean water requirement in oil and gas industries. But, to be successfully reused, the produced water sample wants desirable therapy to meet operational requirements [16]. Produced Water is use in areas the place traditional floor and groundwater sources are scarce, produced water can also be substituted in a variety of industrial practices as lengthy as the first-class of the produced water meets the needs of the industrial technique with or barring treatment. Produced water is already being used for a number of industrial

uses and can also be suitable for others. These are mentioned in this section [14].

III. Management of Produced Water.

Produced water treatment and disposal are topics of growing interest in petroleum operations fields two for three essential reasons: Increasing volumes are being produced as greater and greater fields get mature, Federal Environmental Protection Agency is introducing extra stringent discharge widespread and the need to decrease capital and running cost, especially given the contemporary low oil fees [18]. Moreover, PW therapy has the doable to be an innocent and valuable product rather than a waste, and it could be used for irrigation, more than a few industrial uses and livestock/wildlife watering or energy plant make-up [16, 19]. The foremost goals for operators of PW therapy ought to be investigated as follows:

1. Removal of free and dispersed oil and greases present in PW
2. Removal of dissolved organics
3. Removal of microorganisms, algae and bacteria
4. Removal of turbidity via elimination of suspended particles and colloids
5. Removal of dissolved gases
6. Removal of dissolved salts and minerals, excess water-hardness and possible radioactive materials

For managing produced water, a three-tiered pollution prevention the generally favored hierarchy for environmental administration is: (1) reduce; (2) re-use; (3) recycle/recover; (4) treatment/disposal. These are multiplied on below:

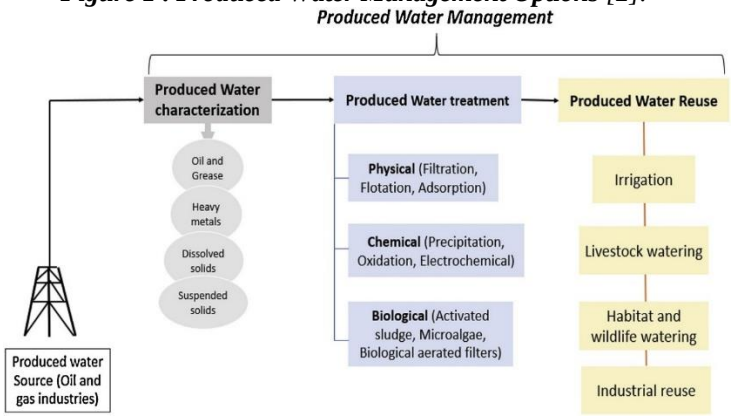
Reduce. two The formation (produced) water is kept in the oil reservoir instead than produced with the oil to surface. Water shut-off treatments (polymers, cement, straddle packers) and re-perforation are practiced.

Re-use. Reuse in oil and gasoline operation: treat the produced water to meet the excellent required to use it for standard oil and fuel fields operations [6]. The produced water is used for re-injection, for reservoir stress renovation or sweep waterflooding. In rare instances with very low salinity, produced water can be re-used, after treatment, for agricultural irrigation or for wash water. Downhole oil/water separation (DHOWS) and re-injection is if truth be told a mixture reduce/reuse option, in which water is separated from oil in the producing well, the usage of an array of hydro cyclones, with an electro-submersible pump (ESP) to pressurize the water for injection to deeper, or shallower zones. DHOWS is solely workable, currently, at a well water-cut above 50% [20].

Recycle/recover. Recovery of heat content material is every now and then practiced, and for uncommon low salinity waters in areas of severe water shortage, desalination to supply potable water has been adopted. However, desalination tactics do lead to a greater targeted effluent move which still has to be disposed of correctly, e.g. through underground injection. Recycling of produced waters for exploration and manufacturing operations within the oil and fuel field is every other principal potential of produced water management. Some therapy can also be required to render the water suitable for reuse in drilling or hydraulic fracturing. Another management approach is the use of produced water for dust suppression and deicing, although some states are looking more.

Treatment/Disposal. Treatment of produced water is an high-quality choice for produced water handling. Treatment of produced water has the viable to be a innocent and treasured product rather than a waste [6]. There are many options for remedy processes, which need to be selected to go well with the final disposal place and environment. two These alternatives are mentioned in further element below. Disposal Options The preferences are: (1) discharge to evaporation pond, if onshore in hot, dry climates; (2) discharge to sea, or other aquatic location (river, lake) if onshore; (3) underground injection by disposal wells [20].

Figure 1 . Produced Water Management Options *[2].*



1.6. Disposal Standards/ Regulations

Discharge of produced water is strictly regulated, though discharge standards differ with location. The quality of produced water is most broadly expressed in terms of its oil content, which acts as a surrogate for different pollutants. Most nations regulate the discharge of produced water, taking into account differing environmental prerequisites and sensitivities between onshore and offshore [21]. Failure to comply with policies can result in: Civil penalties Large fines Lost or deferred production. Currently, guidelines require the "total oil and grease" content material of the effluent water to be reduced to stages ranging from between 15 mg/l and 50 mg/l. Disposal or produced water into onshore surface waters is generally prohibited via environmental regulations. Onshore disposal usually requires the produced water effluent to be injected into a saltwater disposal well.

3.1.1. Onshore Operations

Disposal of produced water into freshwater streams and rivers is generally prohibited without for the very restrained cases where the effluent is low in salinity. Some oilfield brines might kill freshwater fish and vegetation due to excessive salt content. Regulatory requirements for discharge are much greater stringent onshore. In addition to oil and grease, parameters such as biological oxygen demand (BOD) and chemical oxygen demand (COD), TDS, pH, phenols and heavy techniques should meet certain standard [21].

3.1.2. Offshore Operations

Standards for the disposal of produced water are developed with the aid of the authority's regulatory agencies. Regulatory groups generally specify the analytical for identifying the oil content. Produced water toxicity is regulated only in the Nation

the place a government permit is fundamental to restriction toxicity of produced water discharged into the waters. summarizes offshore disposal requirements for several countries. The requirements are cutting-edge The requirements are modern as of this writing [8].

Table 2: Worldwide Produced waste Water Effluent Oil Concentration Standards/Limitations [8].

Country	Oil Concentration/Limitations
Ecuador, Columbia, Brazil	30 mg/l All facilities
Argentina and Venezuela	15 mg/l New facilities
Indonesia	25 mg/l All facilities and Zero discharge to inland water
Malaysia, Middle East	30 mg/l All facilities
Nigeria, Angola, Cameroon, Ivory Coast	50 mg/l All facilities
North Sea, Australia	30 mg/l All facilities
Thailand, Brunei	30 mg/l All facilities
U.S.A.	29 mg/l OCS waters and Zero discharge to inland water

Table 3: The outlet waste water values determined for pH, Sulphide, Nitrogen and Ammonia, COD, Oil and Grease, TSS, BOD and Phenols for comparison with the Chinese and the Sudanese Standards.

Parameter	Maximum limit in Chinese Standards	Maximum limit in Sudanese Standards
pH value at 25°C	6-9	6-9
Sulphide	1 (mg/L)	1 (mg/L)
Nitrogen and Ammonia	15 (mg/L)	10 (mg/L)
Chemical oxygen demand (COD)	100 (mg/L)	150 (mg/L)
Oil and grease	10 (mg/L)	10 (mg/L)
Total suspended solids (TSS)	70 (mg/L)	30 (mg/L)
Biological oxygen demand (BOD)	30 (mg/L)	30 (mg/L)
Phenols	0.50 (mg/L)	0.50 mg/L)

3.2. Impact of Produced Water

3.2.1. Effects on Ecologically important microbial community processes

The results of produced water might also be stimulatory, inhibitory or neutral. Photosynthetic microorganisms are the most important essential producer in marine and fresh water ecosystem, any deleterious results on these most important produced by way of exposure to hydrocarbons and heavy intellectual salts soluble in produced water can alter the tropical shape of the ecosystem [18]. Produced water discharges from offshore oil production comprise a complex mixture of organic substances such as PAH and AP with viable endocrine-disrupting potential [22]. The produced water (at a concentration equivalent to a factor 0.5-1 km downstream from the discharge point) triggered an expand in bacterial biomass but only had a transient, slightly depressant, effect on the price of foremost manufacturing through phytoplankton [23]. The neighborhood structure and variety of microbial communities and activities in the soil ecosystem could be modified beneath the pollution stress. On the other hand, soil micro- organisms and soil enzymatic things to do are touchy biological warning signs of soil pollution [24].

3.2.2. The effects on aquatic lives

Most, but no longer all, produced waters have a salt content material greater than that determined in the local ecosystems. The discharge of water having a greater salt content can have an impact on aquatic organisms. High concentrations of sodium chloride can have an effect on the development of embryos and foetuses and can motive fetal death. High salt concentrations can also affect the development of the musculoskeletal machine and reason eye, skin, and higher respiratory system inflammation [25]. Because the salinity of many produced waters is larger than that of marine waters, the environmental impact of excessive salt concentrations is also of subject involving marine organisms. Highly saline water has a greater density than seawater and will segregate to the backside of any surface waters. This density gradient inhibits the mixing and dilution of the very salty water [11] Produced water effects on aquatic lives are related to the exposure of organisms to concentrations of more than a few chemicals. Factors that have an effect on the amount of produced water elements and their concentrations in seawater, and consequently their doable for have an impact on on aquatic organisms, encompass the following [14]: Dilution of the discharge into the receiving environment, Instantaneous and long-term precipitation, Volatilization of low molecular weight hydrocarbons, -Physical-chemical reactions with different chemical species present in seawater that may additionally have an effect on the concentration of produced water components, Adsorption onto particulate matter, and Biodegradation of organic compounds into different less difficult compounds. APs can have an effect on a number of reproductive parameters in fish, which includes gonadal improvement [26] . Phytoplankton, periphyton and zooplankton, and different important factors of aquatic and marine meals webs, can be affected critically and negatively via disposal of improperly dealt with produced water. Whether these consequences are everlasting or brief depends on a variety of physical and chemical instances atypical to the produced water [18].

3.2.3. Effects on human Health

Life within oil producing areas for instance Niger Delta circles round endeavor that entails every day utilization of the natural water bodies. From the local fishing activities to complicated irrigation work by way of mechanized farmers, the water gadget is known as upon as an indispensable part of their culture. Produced water pollution, thus raises fundamental problems as it affects man not directly form consumption of contaminated aquatic animals and flora and extra at once via his direct usage of the herbal water system. Polluted water cannot be drinkable and its utility price reduced [18]. The have an effect on of HCs on human health relies upon rather on whether or not exposure used to be from ingestion, inhalation, or dermal (skin) contact and on whether the publicity was once acute (short-term) or continual (long-term). The acute results of ingestion can also consist of infection to the mouth, throat, and stomach, and digestive problems and/or damage. Small quantities of HCs can be drawn into the lungs, both from swallowing or vomiting, and may reason respiratory impact. The persistent consequences of ingestion might also consist of kidney, liver, or gastrointestinal tract damage, or odd coronary heart rhythms. Prolonged and/or repeated publicity to aromatics like benzene can also reason damage to the blood-producing system and serious blood problem [11]. he chronic results of ingestion may also encompass kidney, liver, or gastrointestinal tract damage, or strange heart rhythms. Prolonged and/or repeated publicity to aromatics like benzene may additionally reason damage to the blood-producing device and serious blood disorders, along with leukaemia [27].

IV. PRODUCED WATER TREATMENT

3.3. Physical treatment processes

Physical remedy approaches are characterized by way of the capability to separate a range of phases of a waste barring performing any chemical reaction or changing the chemistry of the mixture. Phase separation, such as keeping apart solids from liquids or oil from Petroleum Industries water, is useful in concentrating components or getting rid of free liquids to render a waste suitable for land disposal. By concentrating the material, extra therapy can be completed more economically or conveniently, or recycling/re-use choices may be possible. Typical treatments utilized in this waste management process include: Adsorption Filtration, Flotation

3.3.1. Filtration

Filtration is a method for secondary separation by means of directing go with the flow of produced water via a porous medium that approves passage of the water but retains oil and / or solids. Filters are categorized via the stress difference required to pressure water via the medium by way of the charge of go with the flow / strain relationship and by means of the kind of filter medium used [18]. The drift of produced water through a excellent chosen filter media will reason the small droplets of oil to contact and attach to the filter fibers. Depending on the media format and thickness, these droplets will either remain trapped in the media or ultimately "grow" as other droplets contact them [28]. There are quite a number of porous substances that can be used as filter media, such as sand, crushed stone, and activated carbon. However, the broadly used material is sand due to its availability, low cost and effectivity [2].

3.3.2. Flotation

Flotation is a procedure of getting rid of solids from water by way of using bubbles of air or gasoline to raise strong particles to the surface of the liquid, the place they can be eliminated as floth or sludge [18]. The flotation technique is characterised by means of the following: Involves the injection of excellent gas bubbles into the water phase Gas bubbles in the water adhere to the oil droplets Buoyant pressure on the oil droplet is extensively increased with the aid of the presence of the gasoline bubble Oil droplets are then eliminated when they upward push to the water surface, the place they are trapped in the ensuing foam and skimmed off the surface [28]. Dissolved Gas flotation (DGF) and precipitated gasoline flotation are two subdivisions of the gasoline flotation science and the difference between them is in the technique used for the generation of the fuel bubbles and the resultant bubble size. The efficiency of the method usually relies upon on the contaminants to be removed, density differences of liquids, temperature, and the dimension of the oil droplets [2].

3.3.3. Adsorption

Adsorption is regarded as one of the nice treatment strategies for accomplishing higher water best as it can decrease the concentration of the contaminant to very low level [2]. Adsorption two has been used to dispose of manganese, iron, whole natural carbon (TOC), BTEX, oil and more than 80% of heavy metals existing in produced water [5]. However, there are a variety of adsorbents, such as activated carbon, organoclays, activated alumina and zeolites [29]. Activated carbon can cast off soluble BTEX but organoclay can take away insoluble free hydrocarbons that make contributions to whole petroleum hydrocarbons (TPH) and O&G measurement. Organoclay is produced through combining sodium montmorillonite clay with a cationic quaternary amine salt [6].

3.3.4. Electrodialysis (ED)

Electrodialysis (ED) and electrodialysis reversal (EDR) are each separation processes that are driven by way of electrochemical charge and are used for the treatment of brackish water, seawater desalination and wastewater reclamation, as well as being examined for the therapy of produced water at laboratory-scale [2]. Dissolved salts in water are cations and anions. These ions can connect to electrodes with an opposite charge. In ED, membranes are positioned between a pair of electrodes. The membranes enable both cations or anions to pass by [6]. They use a collection of ion trade membranes containing electrically charged practical web sites organized in an alternating mode between the anode and the cathode to do away with charge resources from the feed water. If the membrane is positively charged, only anions are allowed to skip via it. Similarly, negatively charged membranes enable solely cations to bypass through them. EDR uses periodic reversal of polarity to optimize its operation [5].

3.3.5. Evaporation pond

Evaporation pond is an artificial pond that requires a fairly large space of land designed to successfully evaporate water by means of photo voltaic power [5]. Most of the researchers proposed evaporation techniques for treating saline wastewater containing oil factors Vertical tube, falling film, and vapor compression evaporation are wonderful methods for produced water therapy because they: Eliminate bodily and chemical

remedies so no chemical sludge is produced, and fees of waste and existence cycle are lowered, two require less preservation substances and renovation labor and decrease the amount of produced water de-oiling equipment required [6].

3.4. Chemical treatment processes

Chemical therapy approaches are these in which substances are altered by means of chemical reactions. The chemical reactions can improve or enhance a separation/filtration system or, in some cases, create a product that is in a greater handy shape for further processing or disposal. It includes: precipitation, chemical oxidation, and electrochemical applied sciences

3.4.1. Precipitation

Precipitation is considered as one of the traditional chemical remedy tactics of produced water. Through this process, up to 97% elimination of suspended and colloidal particles can be done [30]. In chemical therapy process, coagulation and flocculation can be used to get rid of suspended and colloidal particles, however are not fine for putting off dissolved constituents. Lime softening is the typical manner for water softening. In the modified warm lime system produced water containing 2000 ppm hardness, 500 ppm sulfides, 10,000 ppm TDS, and 200 ppm oil could be efficiently converted to steam generator satisfactory feed-water. In this process, alkali consumption and sludge manufacturing should be decreased by way of 50% in contrast with traditional warm line [31].

3.4.2. Chemical oxidation

Chemical oxidation in a refinery is commonly used for reduction of residual COD, non-biodegradable compounds, and trace natural compounds. It is not frequent to have a chemical oxidation machine in a refinery wastewater treatment plant; small print of this method is protected in this record for statistics purposes. The following oxidation reagents are usually used in a chemical oxidation system: hydrogen peroxide, chlorine dioxide; and ozone [9]. Chemical oxidation remedy relies upon on oxidation/reduction reactions occurring together in produced water because free electrons can't exist in answer [4].

3.4.3. Electrochemical process

Electrochemical Activation (ECA) technological know-how is a progressive water disinfection technology which entails the publicity of water, and the natural salts, to a good sized electrical possible difference. As an anode (+) and a cathode (-) are placed in pure water and direct current is applied, electrolysis of water happens at the poles leading to the breakdown of water into its constituent factors [32]. In a laboratory pilot-scale plant that protected double anodes with active metal, graphite, and iron as cathode and a noble metallic content crystal with a massive surface, the COD and BOD of oilfield produced water ought to be decreased through over 90% in 6 min. In these processes, produced Mn2+ ions oxidized and coagulated natural pollution consisting of microorganism [6, 33].

3.5. Biological treatment processes

Biological treatment is among the most useful and reasonable techniques for managing petroleum wastewater. Biodegradation is a natural system by using which HCs and different organic substances are fed on by microorganisms (such as bacteria or fungi) that utilize these substances as meals sources. Before starting a organic cure operation, one desires to consider various site-specific parameters to decide the feasibility of successfully biotreating the wastes. A threat evaluation will resource in this decision-making method when regulations do not exist. Biological treatment includes: activated sludge, biological aerated filter (BAF

3.5.1. Activated sludge

Activated sludge is one of the commonly used aerobic remedy method of wastewaters, in which it can adsorb and occlude soluble and insoluble materials [6]. This treatment technique can eliminate trace and suspended solids, in addition to the elimination of metals. Moreover, activated sludge is considered as cheap, clean, and easy remedy technology, but it requires oxygen, massive filter dimensions, and it produces sludge as waste after the treatment procedure is over. It usually requires post-treatment for the separation of precipitated solids, biomass, and dissolved gases [2]. The activated sludge method has the advantage of producing a high first-class effluent for a realistic working and maintenance costs.

3.5.2. Biological aerated filters (BAF)

Biological aerated filter (BAF) is a type of biological technologies which consists of permeable media that uses aerobic prerequisites to facilitate biochemical oxidation and removal of organic elements in polluted water. Media is not more than 4 in in diameter to prevent clogging of pore areas when sloughing take place [5, 34]. Media must have high a surface vicinity per unit volume, be durable, and inexpensive. The kind of media regularly is determined primarily based on what materials are reachable at the site [15]. BAF can do away with oil, suspended solids, ammonia, and nitrogen, chemical oxygen demand, organic oxygen demand, iron, manganese, heavy metals, soluble organics, trace organics, and hydrogen sulfide. Iron and manganese elimination in BAFs is typically due to chemical oxidation instead than a organic process. Since BAFs do not remove dissolved constituents, however, high concentrations of salts can reduce the effectiveness of this technological know-how due to salt toxicity effects [15].

V. CONCLUSION.

Produced water from oil field is often viewed as a high-volume toxic waste however can be useful to human beings if appropriate managed. The remedy of produced water is very vital due to regulation and environmental issues. The main objectives of oil and gas produced water treatment include meeting discharge standards, reusing treated produced water in oil and gas operations, developing agricultural water uses, cattle and animal drinking water, water for human consumption, and meeting water quality requirements for miscellaneous recommended uses. Choice of the quality option for Produced water treatment technology strongly relies upon on the produced water origin, chemical characteristics and space availability in offshore plants.

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