STUDY OF THE UTILIZATION OF OIL AND GAS INDUSTRY WASTE AS AN ALTERNATIVE SOURCE OF IODINE PRODUCTION MATERIALS

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Abstract: The increasing population growth and human needs are accompanied by the increasing technological growth so that the utilization of natural resources (exploitation) as a main buffer of the world's economic system is also increasing. This condition will lead to increased pressure on nature and environmental degradation that ultimately can threaten the development sustainability. In order to minimize or mitigate the impact of environmental risks and threats to the economy, care, awareness, and concrete action by countries in the world are needed to protect nature from damage, through efficient use of natural resources, minimization of negative impacts such as carbon and waste, and community social awareness. Regarding the implementation of blue-green economy where the goal is to process waste into raw materials. The purpose of this study is to analyze the wastewater produced from oil and gas industry wells to be used as an alternative source of iodine production raw materials studied from the content capacity and the level of difficulty of its implementation and find the efficiency of utilization of waste water produced from oil and gas wells which can be used as an alternative source of iodine raw materials production from technical, economic, and environmental aspects. The method used in this study is qualitative exploratory. Based on the study results, it can be explained that the iodine content found is quite significant in the waste water produced from oil and gas industry wells. The content of iodine found is equivalent to iodine content in brine water from shallow wells iodine which ranging from 30 to 40 ppm iodine. Recovery percent of iodine production using wastewater produced by oil and gas industry wells almost equal to recovery percent of iodine using brine water well iodine which is greater than 98,0%. The utilization of wastewater produced from oil and gas industry wells can be used as an alternative source of iodine production raw materials in terms of technical by technically separating petroleum and cleansing the color and soluble / suspended solids using used active charcoal.

Keywords: Iodium, Blue-Green Economy, Oil and Gas Industry, Waste Water Produced
I. INTRODUCTION

Environmental problems such as pollution caused by industrial waste have become a serious problem along with the growing industrialization. This is due to the rapid development of industry without any environmental awareness. The Sustainable Development concept proposed by the World Commission on Environment and Development (WCED), outlined in the book *Our Common Future*, is increasingly relevant and harmonic in addressing these challenges (WCED, 2007). The principle of sustainability has been the reference of many people to criticize the economic development that is less concerned about the environment and equity for the benefit of all community levels, both present and future generations. The Blue Economy concept was formulated to challenge business actors and investment to build more profitable businesses without harming the environment and create jobs. Blue Economy principles on marine and fishery potentials is that managing wisely the abundant potential of marine and fishery by participating to support the economic growth and increase the employment without damaging the environment. The development of chemical raw materials processing industry is very profitable. This is true because it can add more value to products and reduce import dependence, which ultimately affect the state's savings. In addition, the production process using local raw materials and technology can directly create a sense of confidence and independence on the nation regarding the potential and ability in global competition. One of the raw materials / chemical compounds widely used for industrial purposes and only produced in small quantities in Indonesia is iodine. Iodine ($I_2$) is widely used, among others, as a catalyst for chemical reactions, fodder mixtures, ink and paint materials, stabilizers, as an active ingredient of drugs in pharmaceutical industries (e.g. antiseptics, wound medicines, sanitation, disinfectants), photography, organic and inorganic compounds production, as well as a mixture of electric conducting polymers. In Indonesia, iodine is primarily used as a raw material of iodized salt production, especially the raw material of Potassium Iodate ($KIO_3$).

Considering the great potentials of iodine export market and economic, its production capacity in Indonesia must be increased. Iodine production capacity can be increased in two ways. First, the intensification program which is done by PT Kimia Farma by drilling new wells or improving the production process. Second, the extensification program, which is looking for alternative sources of new iodine raw materials. In addition to the drilling of new iodine wells, the intensification process that has been done is the management of iodine gas emissions during the production process with the evaluation result that it can reduce the iodine gas emission to be reused by 44.6% for iodine production process and 83.7% for the production of potassium iodate. Regarding the extensification program, which is looking for alternative sources of new iodine raw materials, one source of alternative raw materials that has been not seriously researched yet in Indonesia is the water of oil and gas drilling associations. Based on the results of surveys and research conducted by a company, actually the wells have a potential iodine deposit. Until now, this liquid waste has not been utilized and just thrown away into the river or sea. Actually, its management can be done in an integrated manner with the oil drilling unit, so it does not require any further investment cost of drilling, in addition to implementing the concept of environmentally friendly (zero emission) and the application of clean technology in the liquid waste processing and disposal.
II. MATERIALS AND METHODS

2.1 Literature Review

Petroleum, natural gas, and coal are created from weathering the remains of living things, thus called fossil fuels. The formation process takes a very long time so that it classified into unrenewable natural resources. Petroleum is often referred to as black gold or liquid gold which is a viscous or greenish liquid, flammable and is in the uppermost of some of the earth's crust and has a very high value in modern society. Agriculture, industry, transportation, and communication systems are heavily dependent on this fuel, thus affecting all life aspects of a nation. Oil and natural gas are the world's major sources of energy, reaching 65.5%, then coal 23.5 %, hydro power 6%, as well as other energy sources such as geothermal, firewood, sunlight, and nuclear energy. The country with a lot of crude oil reserves occupies a favorable position because it has a lot of energy supplies for industrial and transportation purposes, in addition to the importation of state’s foreign exchange through oil exports. Petroleum (Latin: petrus = rock, oleum = oil) is a slippery, flammable liquid and consists mainly of hydrocarbons. The hydrocarbon level in petroleum ranges from 50% to 98%. The rest consists of organic compounds containing oxygen, nitrogen, and sulfur.

Strategies used to reduce or eliminate waste before it resulted (preventive strategy) are preferred over strategies that deal with waste treatment (treatment strategy) (Bratasida, 1997). This strategy consists of Elimination: this strategy is included as a total waste reduction method. If necessary, zero discharge must be put into realization. Regarding the concept of implementing clean production, this is categorized into a method of pollution prevention; Waste minimization (reducing waste source): for reducing waste, the best way is using a strategy that prevent waste production at an early stage. Waste prevention may require several important changes to its process, but it gives the greatest results towards environmental and economic improvement; Recycling: if waste cannot be avoided to produce in its process, strategies to minimize such waste to the highest possible extent should be sought, such as recycle and / or reuse it. If waste production cannot be prevented or minimized through reuse or recycle, strategies that can reduce waste volume through waste management can be done. Although "this end-of-pipe” strategy may sometimes reduce the waste level, however this strategy is not as effective as preventing waste production at its early stage; Pollution control: a strategy that have to be implemented considering the process of production design, the company has not anticipated the presence of new technology that free of waste. This means that waste has already created and is in the production system, but quality and quantity of the existing waste is controlled so as not to exceed the required quality standard; Waste processing and disposal: the last strategy to consider is alternative disposal methods. Proper waste disposal is an essential component of the overall environmental management program, however, this is the least effective technique; and Remediation: strategy of reusing materials disposed with waste. This is done to reduce the poisoning level and the waste quantity existed.

The water produced is an unexpected part in gas mining. The content found in the water is generally halophyte or it has high salt content and some are containing iodine, depending on the well and the formation of the soil layer. One of the raw materials/chemical compounds widely used for industrial purposes and produced in small quantities only in Indonesia is iodine (I₂). It is widely used, among others, as a catalyst for chemical reactions, fodder mixtures, ink and paint composition, stabilizers, pharmaceutical industries as an active ingredient of drugs (e.g. antiseptics, wound drugs, sanitation, and disinfectants), photography, organic and inorganic compounds processing, as well as mixture of electrical conductive...
polymer. In Indonesia, iodine is primarily used as a raw material of iodized salt production, especially the main composition of Potassium Iodate (KIO₃). Iodine is usually found in small quantities in the nature, especially in seawater, rocks, soil and underground water. Its presence is always found together with chlorine which is a halogen group, but chlorine is 2000 times greater than iodine. If stand alone, usually iodine takes form of alkaline salt. The world’s largest iodine source is found in underground water of Japan and caliche and brine deposits in Chile. There is iodine in the form of iodic salt (NaIO₃) and periodic (NaIO₄) in this deposit, which is derived from laurite mineral (anhdyrous calcium iodidate). From this mineral, iodine is precipitated as natrium iodide. Before nitrate reserves developed in Chile in 1808, algae were the most important source of iodine, especially in Japan. Brown algae such as Laminaria family can contain 0.45% of iodine in dried condition and produce 1.4% - 1.8% of iodine after burned under certain conditions.

Iodine is an element of halogens and "trace elements" that are very essential for the environment and human life due to its wide use. Iodine is a mineral substance in the body, means it is an inorganic substance that is very essential for maintaining body functions such as: regulate enzymes work, maintain the balance of acid-base, and form hemoglobin. Micro-minerals are precisely included: iron, manganese, copper, zinc, cobalt and fluorine. Iodine is needed by the thyroid gland to produce thyroxin. Thyroxin is a hormone that regulates the activity of various organs in the body, controls growth, and helps the metabolism process in the body. If the iodine supply in the body is very low, then the thyroid gland will be grown so form a lump in the neck, often called Hypothyroid Disease. The recommended Mineral Sufficiency Rate per person for infants / children (0-6 months) by 90 μg; infants / children (7 months - 12 years) and adolescent girls (10 years - 12 years) by 120 μg; teenage boys (10 years - 12 years) and adults by 150 μg; and pregnant and lactating women of 200 μg - 250 μg per day (J. Untoro 1999).

Sutamihardja (2004) states that targets of the sustainable development include even distribution of development benefits (intergeneration equity), which means that the utilization of natural resources for the sake of development needs to consider the reasonable limits in ecosystem or environment and directed to replaceable natural resources and emphasize the lowest possible exploitation of unreplaceable natural resources. In addition, Barrow (1999) explains that sustainable development is based on the principles of conservation of ecological integrity, the combination of development and environmental conservation, the adoption of an internationalist view (interdependence), benefited conservation, and taking account of equality among generations, groups and species, The application of science technology and environmental knowledge to the development implementation throughout the world, Continued economic growth, and Adoption of long-term views in development. One of the important challenges faced in economic development is how to deal with trade-offs between the fulfillment of development needs on the one hand and efforts to maintain environmental sustainability on the other (Fauzi, 2004). The Blue-economy concept is over 10 years, generating 100 innovations and creating 100 million jobs (Gunter Pauli, 2010). This concept was developed to answer many challenges in the world economic system that tend to be more exploitative and destructive of the environmental ecosystem regarding the waste generated and environmental damage due to excessive exploitation.

2.2 Research Location

This research was taken in 2 (two) locations of oil and gas industry namely Wunut Sidoarjo and Tanggulangin Sidoarjo, and 1 (one) location of iodine production in Watudakon
Jombang Plant. These sites were selected as research location with consideration that there is a significant source of iodine produced from these locations. The timing of the research was started from January 2016 to May 2018 until the dissertation hearing in July 2018. One of the steps taken is literature study. In this phase, theoretical information search is conducted related to the method used for testing iodine content in oil and gas waste, isolation method for iodine contained in oil and gas waste, design of iodine production process with the result of isolation from oil and gas waste. The literature sources used are textbooks, research reports, scientific journals related to the research to be undertaken and existing iodine production processes. The research was started by primary and secondary data collection. Primary data is data obtained from direct observation, research, and calculation. Secondary data is data obtained from continued evaluation of the data obtained for analysis so that hypotheses validity can be proved.

2.3 Testing Methods and Data Analysis

This research takes samples from 2 (two) locations of oil and gas industry namely Wunut Sidoarjo and Tanggulangin Sidoarjo, and 1 (one) location of iodine production in Watudakon Jombang Plant. The sampling point will be taken from several locations of the oil and gas industry production, in order to determine whether there is any effect on the formation of water discharge quality. Samples will be tested for iodine content in oil and gas waste, iodine content isolation method in oil and gas waste, design of iodine production process with isolation result from oil and gas waste. For laboratory-scale experiments, production process requires the material as used in the existing production process. Tests are taken using the suitable reagents based on the applicable specifications. Data analysis used in this research is quantitative and descriptive analysis to technical, economic and environmental aspects. From technical aspect, data on the utilization of iodine industrial waste are those that still contains iodine as a source of alternative materials of iodine production, thus the success or failure of this effort will be seen, it can be a mass balance in the production process which has correlation between oil and gas industry and iodine production industry; production process flow between oil and gas industry and iodine production industry; and maintenance of production, building, and equipment wells. Descriptive analysis takes form of financial analysis on investment value and operational cost, as well as cost saving on production preparation activity based on blue economy followed by explanation of its analysis. While environmental analysis takes form of data collection and continued by analysis based on type and its utilization characteristics. Risk analysis is conducted by taking into account technical requirements to achieve high accuracy. The analysis results are presented in tables, drawings, maps and other forms. Before conducting the initial analysis on environmental data hierarchy, the environmental variables or parameters are formulated and defined in advance. The three aspects tested were technical, economic, and environmental by comparing the source of production materials from the iodine wells and its production process.

III. RESULTS AND DISCUSSION

PT Lapindo Brantas has 2 (two) plants, i.e. Wunut Plant and Tanggulangin Plant. Wunut Plant currently has 6 (six) active gas wells and the Tanggulangin Plant has 3 (three) active gas producing wells. At this stage, the sampling collection was taken on water produced from the gas wells of the two plants and the iodine content in the water produced from each active gas wells was tested. The purpose is to know the gas well point to be studied. The water produced from the gas wells in Wunut Plant is flowed and collected into
the pond. This produced water still contains sand, water and oil. This sand is involved in the gas pumping process because in the gas production layer, where the screen is installed, there is a layer of sand and this created when the gas pumped is thinning then the sand will be brought along with water or oil contained therein. Water produced by the pumped oil and sand is collected in a pond for the evaporation process or also called evaporation pond. The oil is separated manually for further oil processing. For wastewater produced, it is evaporated naturally and if it is considered as proper and cannot be evaporated, it is then injected into the injection well. For the sand, it is left separated because the sand obtained is in the fine form but in high salinity.

**Table 1. Results of Waste Water Produced Test on W#15 dan Ta#2 wells**

<table>
<thead>
<tr>
<th>Type of Tests</th>
<th>Condition</th>
<th>Smell</th>
<th>Iodine</th>
<th>Chloride</th>
<th>TSS</th>
<th>Turbidity</th>
<th>NH3-N</th>
<th>Sulfide (H2S)</th>
<th>Well W#15</th>
<th>Well Ta#2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dark water</td>
<td>Petroleum</td>
<td>38.21 ppm</td>
<td>22.085 ppm</td>
<td>376 mg/l</td>
<td>244 NTU</td>
<td>0.2724</td>
<td>&lt;0.013</td>
<td></td>
<td>Clear yellow water</td>
</tr>
</tbody>
</table>

*Source: Test results of Environmental Quality Test Laboratory of East Java Province, Jasa Tirta Lengkong 2017.*

The treatment of wastewater produced is carried out on W#15 well. The oil phase that has been involved in 7 days has separated in plastic drums. The treatment methods used on wastewater produced from W#15 well include collection on tank reservoir of 8000 liters capacity with a bottom drainage system, to drain the water layer and separate the oil layer, the purification of the black and the suspended solids was taken physically by using a color adsorption system and precipitation of dissolved and suspended solids in the hope of not interrupting the subsequent production process, Determination of the adsorbent mass and type of adsorbent used. Adsorbs analysis was conducted with batch system by using jar test, for determining the active charcoal type used and comparing new activated charcoal and used activated charcoal. There are 2 (two) steps of Jar test, that is the determination of activated charcoal selected from economic aspect and the determination of amount of activated charcoal by considering % removal of TSS and % loss of iodine content obtained. The results are shown as follows:

**Table 2. Test of Activated Characterization Type for Purification**

<table>
<thead>
<tr>
<th>Water Sample</th>
<th>Experiment I</th>
<th>Experiment II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vol 200 mL</td>
<td>Shake 150 rpm, left for 15 '</td>
<td>Shake 150 rpm, left for 30 '</td>
</tr>
<tr>
<td>TSS(0) = 87,8 Cons (0) = 35,78 ppm</td>
<td>TSS</td>
<td>Iodine</td>
</tr>
<tr>
<td>New charcoal 20 g</td>
<td>24.32</td>
<td>13.23</td>
</tr>
</tbody>
</table>
% Removal & 72.3% & 63% & 72.7% & 91% \\
Used charcoal 20 g & 25.88 & 35.11 & 25.56 & 34.02 \\
% Removal & 70.5% & 1.9% & 70.9% & 4.9% \\

**Tabel 3.** Determination Test of Type of Used Activated Charcoal for Purification

<table>
<thead>
<tr>
<th>Water Sample Vol 200 mL</th>
<th>Replication I</th>
<th>Replication II</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSS(0) = 87.8 ppm</td>
<td>Shake 150 rpm, left for 30’</td>
<td>Shake 150 rpm, left for 30’</td>
</tr>
<tr>
<td>Cons (0) = 35.78 ppm</td>
<td>TSS</td>
<td>Iodine</td>
</tr>
<tr>
<td>Used charcoal 10 g</td>
<td>25.85</td>
<td>35.21</td>
</tr>
<tr>
<td>% Removal</td>
<td>70.6%</td>
<td>1.59%</td>
</tr>
<tr>
<td>Used charcoal 15 g</td>
<td>25.8</td>
<td>35.86</td>
</tr>
<tr>
<td>% Removal</td>
<td>70.6%</td>
<td>-0.22%</td>
</tr>
<tr>
<td>Used charcoal 20 g</td>
<td>25.56</td>
<td>35.11</td>
</tr>
<tr>
<td>% Removal</td>
<td>70.9%</td>
<td>1.87%</td>
</tr>
</tbody>
</table>

Based on the experiment, it was found that charcoal used is used charcoal from iodine adsorption process with 10 gram per 200 ml of sample of wastewater produced, shaker speed is 150 rpm for 15 minutes, and left for 30 minutes.

**IV. CONCLUSION**

Based on the results of study and research on the utilization of wastewater produced by oil and gas wells as an alternative material of iodine production, it can be concluded that significant iodine content is found in the wastewater produced by oil and gas industry wells. Iodine content is equivalent to iodine content in brine water of shallow well which is ranging from 30 to 40 ppm iodine, regarding characteristics and specifications of wastewater produced by oil and gas industry well, it is still contained crude oil and is easy to separate naturally, the treated water layer is black and there is a soluble / suspended solid, and the clearance of the produced water layer is effected through the adsorbs process and sedimentation using activated charcoal from the used iodine production process.

**REFERENCES**


Pauli, Gunter. 2010. The Blue Economic: 10 Years 100 Innovations 100 Million Jobs. USA: Paradigm Publications.
Sutamihardja, 2004 Perubahan Lingkungan Global; Natural Resources and Environmental Management Study Program, Post Graduate School; IPB