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Soil Properties of Ship Dismantling Yard at Tanjungjati Village, Bangkalan-District, Indonesia

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Abstract: ***Soil samples from two locations (Soil 1 and Soil 2) of ship dismantling yard at Tanjungjati Village, Bangkalan-district were analyzed. The results showed that both Soil 1 and Soil 2 contained high total petroleum hydrocarbon (TPH), also high concentration of Fe and Mn. The concentration of Pb and Cd in both soil samples were below of critical level for sandy soil. The soil chemical analyze also showed that Soil 1 and Soil 2 had low nutrient content, except phosphor. Soil 1 contained TPH 7.29%, Fe 703.1 mg/kg, Mn 45.2 mg/kg, and Soil 2 contained TPH 9.51%, Fe 226.3 mg/kg, Mn 54.1 mg/kg. The high concentration of those contaminants lead to do remediation in Soil 1 and Soil 2 immediately.***

Keywords: Contaminated soil, Fe, Mn, Ship dismantling, TPH.

1. Introduction

One of known places for ship dismantling activities in Indonesia can be found at Tanjungjati Village, Bangkalan-district, Madura Island. The main target of ship dismantling activities is to get material that can sell in the market, like steel. Mostly steel can be found in vessel constructions. Not only steel, even the ship machine can be sell in the market. Three stages of ship dismantling process in Tanjungjati Village: 1) administration, 2) ship cleaning (pre-cutting), 3) cutting. During ship cleaning, flammable materials such as waste fuels, plastics, glass wools, ropes were taken out to prevent fire incident on the next process. Ship decoating by sandblasting also done to prevent fire incident. Oxy-acetylene cutting technique onshore is used during cutting the ship's body [1].

Cutting process that carried out directly onshore was conducted to soil contamination by hazardous materials, especially because of the ship scraps and disposable materials were stacked haphazardly. Hazardous materials produced from ship dismantling activities are Polycyclic Aromatic Hydrocarbon (PAHs), Polyvinyl Chloride (PVC), Polychlorinated Biphenyl (PCB), heavy metals, Tributyltin (TBT) [2]. Those scraps were causing accumulation of metal fragments and rust (particularly iron) in the soil [3]. Heavy metals such as lead and cadmium concern were related to ship dismantling activities. Those are inessential metals that can injure human health and ecological systems. Other metals also could be found in the ship dismantling industry are manganese, nickel, chromium, copper and zinc [4]. Organic contaminant, the hydrocarbon compounds can be from tanks, pipes, machines, ballast water, waste fuel, waste oil and grease that were obtained during the cleaning process of the vessel [5]. Not only highly risk of seawater and sediment pollution, the soil quality will be decrease due to the presence of hydrocarbons, metals, and heavy metals because of ship dismantling activities. Soil quality of ship dismantling yard at Tanjungjati Village were examined to be able do the remediation immediately.

2. Material and Methods

2.1 Soil Collection

Soil samples were collected from two ship dismantling yards in Tanjungjati Village (Figure 1), Soil 1 (7°10'16.06"S; 112°44'3.84"E) and Soil 2 (7°10'15.83"S; 112°43'55.79"E). Soil from twelve sampling points in each ship dismantling yard homogenized as one composite soil sample and it was taken manually by hand auger with depth 0-30 cm.

2.2 Soil physicochemical analysis

The soil parameters that analyzed in this study (Table 1) were conducted by following Indonesian Technical Guidelines Soil Chemical Analyzes [6]. The available of metal and heavy metal (Fe-, Mn-, Pb, and Cd-available) in soil samples were conducted by using EDTA 0,05 N solvent (pH adjust 7,00). Soil samples were agitated with solvent for one hour and filtrated before determined using atomic absorption spectrophotometry (AAS).

TPH level in soil samples were carried out by ultrasonic water bath extraction and calculated following gravimetric method [7]. Soil sample 10 gr, anhydrous Na_2SO_4 10 gr, and n-hexane 35 ml were put into Duran 100 ml. Extraction were done for 1 h with 50°C in an ultrasonic water bath (Krisbow, Indonesia). The extractant was filtrated with glass wool, then 25 ml n-hexane added to get 60 ml final volume of supernatant. Supernatant was put into a flask and kept in a fume hood for 3-4 days.

Figure 1: Sampling location (source: GoogleEarth)

3. Result and Discussion

The difference of Soil 1 and Soil 2 occurred due to the ship dismantling activities in Soil 2 already did for 4-5 years earlier than activities in Soil 1. That could aim more metals, heavy metals, and hydrocarbon accumulated in Soil 2 compared to Soil 1. Based on data interpretation of Indonesian Technical Guidelines Soil Chemical Analysis [6], Table 1 showed that both of soil samples were categorized as slightly alkali sandy loam with low content of nutrient except phosphorus compounds. Both soil samples were dominated by sand indicated that the soil has rough surface texture and contained small amount of colloids. CEC value of Soil 1 was higher than Soil 2, it was 2.35 cmol/kg and 1.93 cmol/kg respectively. There was relation between cation exchange capacity (CEC) and soil texture. The CEC value decreased if the soil texture getting more rough and less content of colloid [8]. Similar to texture analysis results showed that Soil 1 contained more silt and clay compared to Soil 2, indicated more colloidal found and also related to more cations easily to bond in Soil 1. Most of cations in both soil samples were found in low value, except Na cation that extremely in high value. The domination of Na cation was causing the increase of pH value in both soil samples (pH 7.9). The high value of Na cation related to the sampling location condition. Both soil samples were taken from two locations that geographically next to sea.

The more clay matter in soil usually lead to the greater soil capacity to hold water. Soil 1 contained more water and higher holding capacity (WHC) compared to Soil 2 that could cause by Soil 1 had more clay matter than Soil 2. Besides of its clay matter, Soil 1 also contained less hydrocarbon compound compared to Soil 2. TPH levels were 7.29% in Soil 1 and 9.51% in Soil 2. The TPH level in both soil samples were highly above of maximum level (TPH 1) [10].

That condition showed that most of hydrocarbon in liquid phase already fill the pores of Soil 2. That could aim the Soil 2 was easily loss its moisture and less presence of the oxygen compared to Soil 1. That also could inhibit the process of hydrocarbon degradation by microorganisms. The presence of hydrocarbon could increase organic matter and carbon in soil, also decrease of the phosphor, magnesium, calcium, sodium, potassium [12],[13]. The more TPH level in Soil 2 aimed to decrease of phosphor, magnesium, and sodium compared to Soil 1.

Table 1: Soil properties

		Soil 1	*Soil 2*
Texture	Sand	87 %	90 %
	Silt	8 %	6 %
	Clay	5 %	4 %
pH H_2O		7,93 SL	7,91 SL
Water content (%)		6,43	4,35
C-organic (%) - Walkley & Black		1,88 L	2,82 M
N-total (%) - Kjeldhal		0,11 L	0,08 L
P-available (ppm) - Olsen		155,45 EH	16,14 L
P-total (mg/100 gr)		144,34 EH	98,06 EH
CEC (cmol/kg)		2,35 EL	1,93 EL
Ca (cmol/kg)		5,34 L	5,96 L
Mg (cmol/kg)		0,61 L	0,35 EL
K (cmol/kg)		0,38 M	0,38 M
Na (cmol/kg)		1,93 EH	1,51 EH
K-total (mg/100 gr)		3,75 EL	1,53 EL
C/N		17 H	35 H
Water holding capacity (%)		17	7
Fe-available [a)] (mg/kg)		703,1 H	226,3 H
Mn-available [b)] (mg/kg)		45,2 H	54,1 H
Pb-available [c)] (mg/kg)		8,8 L	11 L
Cd-available [d)] (mg/kg)		0,1 L	0,3 L
TPH [e)] (%)		7,29 H	9,51 H

SA = slightly alkali; EL = extremely low; L = low; M = moderate; H = high; EH = Extremely high. [a)] Fe critical level: 3,4 mg/kg; [b)] Mn critical level: 1,2 mg/kg; [c)] Pb critical level: 64 mg/kg; [d)] Cd critical level: 5,5 mg/kg; [e)] Maximum TPH: 1% [9]–[11].

The P-total in both soil samples showed in extremely high value, but value of P-available in Soil 1 were much higher compared to Soil 2. The high value of P-available could relate to more phosphate compound in Soil 1. That also could be the reason more Fe found in Soil 1 compared to Soil 2. There was antagonist effect between Fe and Mn. Higher Fe

concentration could decrease Mn absorption [14]. That explained Soil 1 contained higher Fe concentration and lower Mn concentration compared to Soil 2. Besides that, the Pb and Cd concentration in Soil 2 was higher than Soil 1. It could relate to the C-organic value that in Soil 2 higher than Soil 1. Organic matter had high affinity to bond heavy metal. Metal ion perform as electron acceptor and ligand, substance that could react with ion, perform as electron donor (Utomo et al., 2016).

TPH levels were 7.29% in Soil 1 and 9.51% in Soil 2. The TPH level in both soil samples were highly above of maximum level (TPH 1%) according to Indonesian Environment Indonesian Environment Ministry Decree number 128 (2003). Critical level of Fe, Mn, Pb, Cd in sandy soil is 3.4 mg/kg, 1.2 mg/kg, 64 mg/kg, and 5.5 mg/kg, respectively (Elgala et al., 1986; Vries et al., 2007). Based on the result of soil chemical analysis, the concentration of Fe and Mn were above of critical level, but concentration of Cd and Pb were below of critical level. The soil chemical properties indicated that Soil 1 and Soil 2 should remediate immediately to reduce the concentration of TPH, Fe, Mn.

4. Conclusion

The soil of ship dismantling yard at Tanjungjati Village, Bangkalan district is slightly alkali sandy loam that contaminated with hydrocarbon, Fe, and Mn. Low nutrient content, but high phosphorus found in Soil 1 and Soil 2. The high TPH level, also high Fe and Mn concentration are the reason that remediation should be do immediately in Soil 1 and Soil 2.

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