Survey of Environmental Baseline in the Nunukan Agriculture Area, Indonesia

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ABSTRACT

South Nunukan District has a complex ecosystem which has the river, terrestrial, coastal and oceanic ecosystems, and has been demarcated by the Government of The Nunukan Regency for agricultural purposes. This research was conducted to determine the preliminary environmental baseline of agricultural activities that have been and will take place in this region. Methods of measuring environmental quality were carried out by (1) measuring water quality by taking water samples at four locations and tested in a laboratory; and also measuring aquatic biota by taking samples in rivers and testing at a laboratory, (2) measuring air quality at three sample locations using an air quality meter, and noise using a sound level meter, (3) measuring soil quality by taking five samples at the study site and conducting soil quality testing in the laboratory. The result of this study concluded that this area is suitable to be used as an agriculture and plantation area by adding various engineering technologies and fertilizing. This is supported by the results of water, air, noise and soil quality tests from several samples showing the average within and bellow the permissible limit (WPL and BPL). For a small number of parameters that do not meet quality standards (APL), environmental engineering efforts need to be done.

INTRODUCTION

The progressive development of cities in the world including the Industrial Acceleration in the last two decades has brought many impacts on the environment, which are caused by pollution in water, soil and air that in turn can disturb human health (World Health Organization 2002, Sattar et al. 2012, Rashid et al. 2014).

Indonesia is an archipelagic country and Nunukan island is one of the islands located in the Kalimantan region. Based on the Spatial Plan of the Nunukan Regency 2013-2033, the South Nunukan District is intended for agriculture and plantation areas. To support these objectives, environmental conditions that are appropriate for their purpose are needed. South Nunukan District is geographically affected by river ecosystems (Tanjung Harapan River), terrestrial, coastal and oceanic ecosystems so that this region has complex conditions.

As an area designated for food storage, water is a vital part because it is a basic need for irrigation and other agricultural needs (Kumari et al. 2009). The rise of population, modern agriculture, and industrialization can put gigantic pressure on freshwater bodies, causing a threat to mankind's healthy existence (Karne et al. 2009). To reduce the environmental damage caused by development, preliminary studies are needed to see the baseline environment, this is aimed at realizing sustainable development (Sari et al. 2014).

This study has been conducted to evaluate environmental parameters in water, air and soil. Furthermore, water quality has been measured in several areas such as a river, reservoir, surface water and groundwater around South Nunukan District. The assessment of water quality can support the function of the land. By using water variable, this study measures the physicochemical and biological characteristics of the water body and groundwater as study areas and compare them to The Indonesian Government Regulation Number: 82 of 2001, concerning Water Quality Management, Control and Diversity Index of Shannon-Wiener.

Also, measurements of air quality and noise were carried out around South Nunukan District where most of the cities in Indonesia have been reported for particulate air pollution and give an impact on the environment (Sattar et al. 2014, Saini et al. 2018, Sattar et al. 2019). Finally, soil quality was also analysed to determine soil fertility in the study area.

MATERIALS AND METHODS

Study Area Description

The population of South Nunukan District in 2018 was 26,827 occupying an area of 174.4 km^2. Population growth that occurred as a result of the development was almost evenly distributed in each district so that it attracted newcomers to live and settle in South Nunukan subdistrict. The opening of employment in the plantation sector, especially oil palm and the wood processing industry and the service sector was another reason why more people feel attracted to move and live here (BPS-Statistics of Nunukam Regency 2016).

The South Nunukan district is located around the catchment of the Tanjung Harapan River in Nunukan Island and situated on the edge of the southern coast (117°40'34.39" E, 3°58"25.36" N). This area was planned as an integrated agricultural production zone. This land is called transitional swampland or tidal swamp where the strength of tidal currents from the sea is slightly greater or equal to the strength of currents from the headwaters of the river. Fig. 1 shows the location of the island.

Sampling Methods

The sampling sites are shown in Fig. 1. The samples were collected at four areas including river, groundwater, surface water and reservoir water in the South Nunukan District in plastic bottles before rinsing them with the sample water. The water samples were then brought to the laboratory for physicochemical quality and biological parameters testing. The methods follow The Indonesian Government Regulation Number: 82 of 2001, concerning Water Quality Management and Control.

Biological measurement was done using the indicator of aquatic biota (Holt & Miller 2010). Plankton was sampled
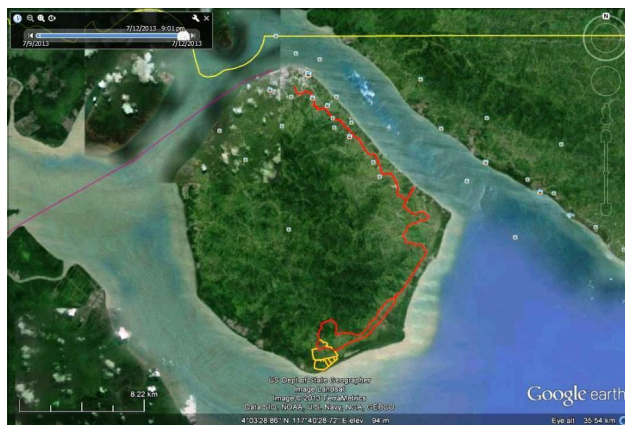
(Source: Google Earth, 2020)

Fig. 1: The location map.

using a plankton net by filtering 100 litres of water. Then, it was stored in 10 mL plankton bottles and preserved with 4% formalin solution to be observed in the laboratory. The plankton was separated into phytoplankton and zooplankton groups, to determine the diversity of species and their abundance. Plankton's determination was made by using the key of plankton determination made by Shirota (1966).

For air quality measurements, samples were taken from 3 locations and the measurement was made at the site using an ambient gas sampler (Impinger Model: MD-51MP), while measurement of noise levels at locations using a sound level meter.

To determine the level of soil fertility in the study area, identification and analysis of the physical (sand, dust and clay) and chemical properties of the soil were carried out through soil analysis, i.e. pH, C, N, C/N, P_2O_5, Ca, Mg, K, Na, KTK and BK. The soil samples were taken from 5 locations and brought to the laboratory for analysis with reference to the guidelines of soil analysis (BPN-Institute of Soil Research 2003).

RESULTS AND DISCUSSION

Water Quality

The results of the study for all parameters are given in Table 1. Based on various physicochemical parameters, each water sample was classified into within permissible limits (WPL), below permissible limits (BPL) and above permissible limits (APL).

The Total Dissolved Solids (TDS) is defined as the total amount of the solid material dissolved in water containing salts, dangerous metals and other materials in water. The results of the analysis of TDS in Sample 4 (S4) are higher than those of Sample 1, Sample 2 and Sample 3. The order of TDS concentration found at the sampling site was S4 > S1 > S3 > S2, even the concentrations in S4 and S1 exceed the permissible limit (1000 mg/L). The results of these measurements indicate that the river water in the planned location of the activity has been polluted. The sulphates showed the highest concentration at S4 (489,881 mg/L) which exceeds the permissible limit (400 mg/L), while S1, S2 and S3 have still below the permissible limit. The dissolved oxygen (DO) exceeds the permissible limit (> 6 mg/L) at all the 4 sample locations, while the total phosphorus as P was only present at S1 which exceeds the permissible limit (0.2 mg/L) with a concentration value of 0.872 mg/L. The concentration of P at S1, S2 and S3 were not below the detection limit.

The measurement of water quality in Table 1 shows that the Dissolved Oxygen (DO), Cl, and sulphate parameters are high, but these values are considered to still meet the class

Table 1: The physicochemical, dissolved metal and microbiological parameters of 4 water samples in the South Nunukan District.

Physic Parameters	S1	S2	S3	S4	PL
Temperature	28	28	28	28	
TDS	1350 (-)	144	296	5628 (-)	1000
TSS	23.6	10.8	13.2	4	50
Dissolved Metal Parameters	S1	S2	S3	S4	
As	-	-	-	-	0.05
Co	-	-	-	-	0.2
Ba	-	-	-	-	1
Br	-	-	-	-	1
Se	-	-	-	-	0.01
Cd	< 0.0003	< 0.0003	< 0.0003	< 0.0003	0.01
Cr^{6+}	0	0	0	0	0.05
Cu	< 0.0001	< 0,0001	0,0066	0.0066	0.02
Fe	0.463 (-)	0.015	0.118	0.041	0.3
Pb	< 0.0074	< 0.0074	< 0.0074	< 0.0074	0.03
Mn	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.1
hg	-	-	-	-	0.001
Zn	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.05
Cl	547.836 (-)	15.762 (-)	15.762 (-)	102.24 (-)	600
CN	-	-	-	-	0.02
Fluoride	-	-	-	-	0.5
NO_2 as N	0	0	0	0	0.06
Sulphate	51.079 (-)	19.693 (-)	74.644 (-)	489.881 (-)	400
Cl_2	0	0	0	0	0.03
H_2S	0	0	0	0	0.002
Microbiological Parameters	S1	S2	S3	S4	
Coliform	93	23	32	14	1000
Chemical Parameters	S1	S2	S3	S4	
pH	7.29	6.94	7.02	7.09	6.0-9.0
BOD	1.044	0.959	0,98	0.928	<2
COD	5.493	5.049	5.16	4.882	<10
DO	6.972 (-)	7.049 (-)	6.962 (-)	7.418 (-)	>6
Total Phosphate as P	0.872 (-)	0	0	0	0.2
NH_3-N	0.097	0	0.436	0.989	10

*Where: (-)= Above permissible limits, - = Not Analysed; 0 = Not detected
*Where: S1-River Water, S2-Groundwater, S3-Surface Water, S4-Reservoir Water, PL-Permissible Limit

I water criteria based on Government Regulation Number 82 Year 2001, concerning Water Quality Management and Control Water Pollution.

The phosphate (P) is above the permissible limit at the S1 (river water) test location, this shows the occurrence of river pollution by agricultural fertilizers entering the river water through drainage and rainwater flow. This causes high growth of algae in river water (eutrophic condition) which will cause the reduction of dissolved oxygen endangering the river water ecosystem. Table 2 gives the range of plankton diversity index which is 1.32, this value shows that the quality of river waters is in the moderate polluted category. The uniformity and dominance index show stable conditions and there is no type of plankton domination.

According to Wilhm (1975), based on the zoobenthos diversity index, water quality can be categorized as heavily

Table 2: The phytoplankton of Tanjung Harapan river samples in the South Nunukan District.

Phytoplankton	Result (ind/m^3)	Benthos	Result (ind/m^3)
Asterionella sp.	166	Corbicula	95
Skeletonema sp.	166	*Melanoides* sp.	31
Chaetoceros sp.	333	*Pilsbryconcha* sp.	31
Zooplankton			
Moina sp.	166		
Plankton		Makrozobenthos	
Total Abundance	831 (ind/m^3)	Total Abundance	157 (ind/m^3)
Number of types	4 types	Number of types	3 types
Diversity Index	1.32	Diversity Index	0.94
Uniform Index	0.96	Uniform Index	0.85
Dominance Index	0.28	Dominance Index	0.56

*Where: (-) Above permissible limits

polluted (0 < H' < 1), moderate polluted (1 < H' < 2), lightly polluted (2 < H' < 3) and is very lightly polluted (3 < H < 4.5). The range of H' values is part of an assessment of water quality with the physical chemistry of water. Lee et al. (1978) stated that the diversity index value (H') in heavily polluted waters, smaller than one (H' < 1), moderately polluted (1.0-1.5), lightly polluted (1.6-2.0), and not contaminated by a large H of two (H > 2.0). The category of water quality and pollution level based on Shannon-Weiner's macrozoobenthos diversity index are divided into four groups, as given in Table 3.

The macrozoobenthos community of the three river water stations has a density of a range of 157 individuals/m^3, 3 types of macrozoobenthos which belong to 2 groups, including Bilvalvia, 2 types namely *Corbicula* sp. and *Pilsbryoconcha* sp., Gastropod Class 1 types namely *Melanoides* sp.

The results of the diversity index analysis show that the waters of the river have been heavily polluted, the range of diversity index is < 1, as well as the index of uniformity, the range of 0.85 indicates the individual distribution of each species in heavy and unstable conditions, while the level of dominance index tends to be high at 0.56 shows that some types dominate abundance or that each individual cannot

Table 3: Pollution rate classification (Lee 1978).

Shannon Index	Water Quality	Pollutant Category
<1	Slight	Heavy Pollution
>1-2	Light	Moderate Pollution
>2-3	Moderate	Light Pollution
>3-4.5	Good	Moderate Pollution/ Not Polluted
>4.5	Heavy	Not Polluted

utilize resources optimally. It seems that there are more abundant species than other types.

Air Quality

Based on the results of the measurement of air quality using the Indonesian Standard Number 41 of 1999, concerning the Quality Standards of the National Ambient, all parameters are below permissible limits (BPL) which indicates that air pollution does not occur, as given in Table 4.

Noise Quality

Based on the results of noise measurement using the Indonesia Minister of Environment Standard Number 48/ MENLH/II/1996 concerning Noise Level Standards, no air pollution occurs (BPL) because there is no value above 70 dBA (Table 5).

Soil Quality

Laboratory analysis results in Table 6 show that in general soil conditions at the study site have moderate fertility with clay texture about 33-47% clay composition.

Soil fertility was relatively low, especially for the macro nitrogen element, but has a moderate phosphating content. Levels of organic soil C are very low at 1.64-2.69% of the ideal 5%, so fertilization with organic fertilizer is highly recommended before planting. The content of macroelements N 0.16-0.21% or very low to low, this requires the addition of urea fertilizer large enough to meet the needs of plant nitrogen.

Fig. 2 presents information about the general soil conditions in South Nunukan Subdistrict, Nunukan Regency which has a moderate fertility rate with a clay texture having 33-47% clay composition, 15-31% dust and the 4% sand. Soil fertility is relatively low, especially for the macro nitrogen element but it has a good phosphate content. The type of

Table 4: Air Quality in The South Nunukan District.

Parameter	S-1	S-2	S-3
Sulphur Dioxide (SO$_2$)	20.879	26.098	24.326
Carbon Monoxide (CO)	39.502	25.393	19.220
Nitrogen Dioxide (NO$_2$)	23.786	40.588	35.365

Where: S1-River Water, S2-Groundwater, S3-Surface Water, S4-Reservoir Water

Table 5: Noise measurement.

Parameter	S-1	S-2	S-3	PL
dBA	52.6	47.3	45.1	70

Where: S1-River Water, S2-Groundwater, S3-Surface Water, S4-Reservoir Water, PL: Permissible Limit

Table 6: The results of soil analysis samples.

Soil Parameter	S1	S2	S3	S4	S5
pH	4.2	3.8	5.5	4.9	4.5
C	2.21	1.89	2.14	2.69	1.64
N	0.17	0.16	0.18	0.21	0.16
C/N	13	12	12	13	10
P2O5	9.23	8.24	7.66	10.56	9.33
Ca	4.26	3.52	3.22	2.98	4.13
Mg	2.16	1.63	1.89	1.99	2.07
K	0.25	0.19	0.33	0.21	0.17
Na	0.39	0.24	0.22	0.26	0.27
KTK	23.07	24.32	24.36	21.85	21.66
KB	31	23	23	25	31
Texture					
a. Sand	41	35	29	34	49
b. Dust	15	32	24	31	15
c. Clay	44	33	47	35	36
Texture Class	Clay	Clay Stick	Clay	Clay Stick	Sand Clay

Source: Survey, 2015

Fig. 2: Land condition.

soil has less organic matter so that it can stabilize the soil structure and be resistant to erosion. The content of organic matter determines the sensitivity of the soil to erosion as the organic matter affects the structure of the soil. Soils that contain enough organic matter generally cause the soil structure to become stable so that it is resistant to soil erosion (Sarief 2001). Organic soil C levels are very low, i.e. 1.64-2.69% of the ideal 5%, so fertilization with organic fertilizer is highly recommended before planting rice to enable the soil in binding water be maximized. The content of macroelements N (0.16-0.21%) or very low to low level and this requires the addition of urea fertilizer large enough to meet the needs of plant nitrogen (Hanafiah 2010).

CONCLUSION

Based on the environmental baseline data of the South Nunukan District, it can be concluded that this area is suitable to be used as an agriculture and plantation area in accordance with The Nunukan Regional Spatial Plan (2013-2033) by adding various engineering technologies and fertilizing.

This is supported by the results of water, air, noise and soil quality tests from several samples showing the average below permissible limit (BPL). It was found that for some parameters, which did not meet the quality standards, some environmental engineering actions should be taken.

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