WATER QUALITY AND WATER POLLUTION STUDY BASED ON GEOGRAPHIC INFORMATION SYSTEM IN BILI-BILI RESERVOIR, GOWA REGENCY, SOUTH SULAWESI

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ABSTRACT

Natural resources management that are not environmentally friendly lead to unsustainable resource utilization. It cause there is no guarantee for natural resources can be developed to satisfy the needs of life in the future. During this time, Bili-Bili reservoir has an important role as a source of raw water to people in Gowa Regency and surrounding areas. The development of human activities along the Jeneberang river as the main river in the watershed such as agricultural activities, settlements, tourism, and sand quarrying, trigger changes in river water quality that have an impact on water quality in the Bili-Bili reservoir. Based on the problems it is important to analyze the water quality of the reservoir, and determined of water quality status based on the applicable water quality standards and Minister of Environment Decree No. 115 of 2003. The development of activities in Jeneberang watershed were become factors that trigger changes in water quality. Spatial analysis was conducted to determine the distribution of activity that could potentially contaminate the water. Through two analyzes are expected to be the basis for the formulation of recommendations in Jeneberang watershed environmental management, especially in Bili-Bili reservoir. Water quality status of Jeneberang watershed showed that all water samples were in moderately polluted. It happened because some exceed value of the water quality parameter, such as TSS, Ammonia, Nitrate, phosphate, and oil content. human activities arround the study area showed that the contamination came from household activity, agriculture, sand quarrying, and also tourism waste.

Keywords: water quality, water pollution, geographic information system

INTRODUCTION

The amount of land required are increase in line with the population growth. Forest area changes become agriculture land, settlement area, and others, which created many negative impacts to the land and water resources that occur onto watershed area (Syamsudin, 2012). People activities arround the river tended to increase in order to comply their life nesessities, it's caused by population growth and economic. These factors bring the possitive and negative effects to the environment in watershed area, the degradation of water quality, especially in water utilitization for drink of the communities. Jeneberang River is one of the river in Gowa Regency, South Sulawesi Province, that influenced by human activities. It has the Dam Bili-bili as the

downstream, which is used for some water resources in human activities around the area in South Sulawesi.

Dam Bili-bili water are supplied from Jeneberang river, which is one of big and important river in South Sulawesi. The water flow across Gowa Regency, Takalar Regency, and Makassar. Jeneberang is part of the watershed that supply the water to city Makassar. It has the downstream in Makassar strain, that also provided from east of Mount Bawakaraeng (2.833 mdpl). Jeneberang Watershed has two main reservoirs, that are located in Bili-bili and Jenelata. The waters are taken from Jeneberang river that located on 7 kilometers at south of the city, pumped through covered pipeline to Ratulangi instalation. This river also provide clean water supply of Makassar and Sungguminasa Subdistrict Gowa Regency.

Badan Lingkungan Hidup Daerah (BLHD) or Environmental Agencies of South Sulawesi claimed the river water quality that cross Gowa Regency and two subdistrict in Makssar are in bad quality. This water commonly are polluted by the material of erosion in coastal area, its caused by deforestation. Water pollutions are also affected by sand quarry activities on the river. The other activities as the problem in Jeneberang river area are agriculture, household waste, and tourism activity.

Based on the background of the outlined problems, this research aimed to study the water quality status of Dam Bili-bili Jeneberang Watershed, analyse the environmental pollution in Dam Bili-bili, and study the spatial distribution of human activities around the Jeneberang river potentially cause environmental pollution in the Bili-Bili Reservoir.

Material and Method

This research was conducted at Dam Bili-bili, a part of Watershed Jeneberang. This reservoir is the downstream of the watershed. The location is located in Gowa Regency, South Sulawesi Province (Fig.1).

Method for the research is survey method. The datas were collected by measurement of variables and interviewed the informants. This method aim to collect primary data of the water quality. As complementary, this study also supported by secondary data such as instantional data and the result of the similar researches done before. All datas were analysed as qualitative and quantitative in order to have the description of the problems, and the spatial distribution of each objectives in research area.

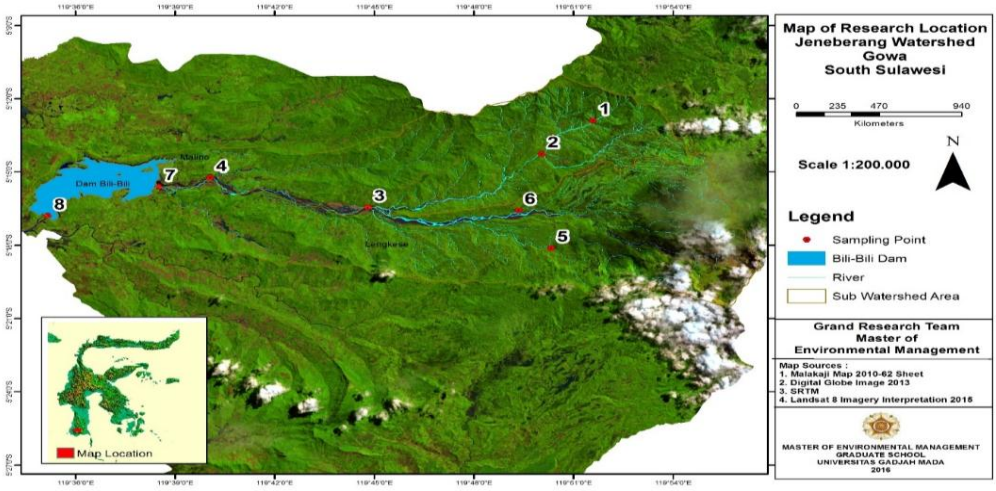

Figure.1.Map of Study Location.

Primary data collection is done through water sampling, aimed to determine water quality data through testing. Sampling points were selected based on water flow analysis of watershed Jeneberang, using remote sensing imagery. Based on the spatial analysis, it is determined eight sample points. The points were considered as the difference of order, and diversification of the morfology that indicate of activities around the river. Water sampling was done once for each point. Water samples were stored in 1 liter sample bottles for each.

Water quality status were analyzed as qualitatively and quantitatively, based on the result of laboratory test of water quality for both chemical and physic parameters. Data were analysed based on Goverment Regulation No.82/2001, class II for the river water and for the reservoir. Water quality standard for each parameter at Table 2.

Table 1. Sampling points.

No	Station	Coordinate	Information
1	Station I	50M; x816201 y9421235	Water spring from sub-watershed Malino
2	Station II	50M; x816118 y9419476	Point after settlement area
3	Station III	50M; x804425 y9416352	Meet point of 2 sub-watershed
4	Station IV	50M; x795060 y9418288	Point after sand quarrying.
5	Station V	50M; x815754 y9411826	Water spring from sub-watershed Lengkese
6	Station VI	50M; x812992 y9416145	Point after Malino City
7	Station VII	50M; 793130 y9418053	Point before Reservoir Bili-bili
8	Station VIII	50M; 786643 y9415843	Point before reservoir of Dam

Table 2. Parameter

Parameter	Unit	Standard quality Class 2	Measurement site
Temperatur	^{o}C	deviasi 3	In situ
Total suspended solid (TSS)	mg/L	50	Laboratory
Total dissolved solid (TDS)	mg/L	1000	Laboratory
pH	-	6,0 – 9,0	In situ
DO	mg/L	4	Laboratory
BOD	mg/L	3	Laboratory
COD	mg/L	25	Laboratory
Oils	ug/L	1000	Laboratory
Nitrate (NO_3)	mg/L	10	Laboratory
Ammonia (NH_3)	mg/L	≤0,02	Laboratory
Phosphate	mg/L	0,2	Laboratory

1.1. Pollution Index

Pollution index or PI is one of method of measurement water quality status to determine pollution or contamination level relative on permitted water quality parameter. The classification of water quality status are base on PI score (Minister of Environment Decree No.115/2003) at Table 3.

Table 3. Pollution Index

No	PI score	Category
1.	$0 < PI_j < 1,0$	Good water quality
2.	$1,0 < PI_j < 5,0$	Moderately Polluted
3.	$5,0 < PI_j < 10$	Polluted
4.	$PI_j > 10$	Extremely Polluted

1.2. Spatial analysis

Spatial analysis was needed to describe the distribution of activities that potentially affect the contamination in the water. This method is conducted to obtain the relationship between the water quality analysis result and human activities. It can be use to know the trigger factors to create potential pollution around the river. This spatial analysis also supported by interviews with relevant stakeholders to obtain data on their perceptions of river condition and also reservoir.

RESULT AND DISCUSSION

Temperature, Total Suspended Solid (TSS), and Total Dissolved Solid (TDS)

Jeneberang Watershed are consist by Jeneberang river and Bili-bili as reservoir. River water are classified as water for class II, it is used for infrastructure, water recreation facilities, freshwater fish culture, animal husbandry, and irrigation. Bili-bili reservoir is used as source of raw water for drinking water to the city and other region, based on this utilization the water in reservoir are categorized as class II that will be be treated in a purifying system by PDAM.

Water temperature in sample areas is ranging from 22,7 to 28,6^{o}C. The condition on point 1, point 2, point 5, and point 6 are in natural environment on mountainous area. Total suspended solid of water showed that most of the water sample in quality standard. The exceed value are in Point 4 (107,9 mg/L) and Point 7 (78,9 mg/L). The highest value of TSS is in Point 4 which occur in the area where sand quarrying activity found. This activity takes places on water bodies of the river. Sand quarrying has been going on for years, everyday, then it caused the material were flowing into the water flow of river.

TSS is derived from suspended material such as sand, and mud. Facts on the data found is believed base on the TSS datas in other points, that there are no over standard quality of TSS value found in around settlement, agriculture, or tourism area. TSS content in the water will influence the water temperatur, and turbidity. This is because the heat of sunlight will be absorbed by the solid material then increase the temperature. The daily discharge Jeneberang river is 128 m3/dt. TSS concentatration will decrease if the water debit increase while rainfall. High TSS in Point 7 might caused by the accumulation from the river, and also the errosion on the ground in the wall river. Based on the information from Watershed Agencies for Pompengan Jeneberang that One of the problems in reservoir Bili-bili is erosion occurring that impact on the occurrence of sedimentation.

Total Dissolved Solid in this watershed range 19-56 mg/L. All TDS value for each water sample met the quality standard that requires <1000 mg/L. The highest TDS occur at Point 4 where sand quarrying were located, and Point 7 is in the point before reservoir Bili-bili. But the whole, water samples show a value in standar quality.

pH and Dissolved Oxygen (DO)

pH values on every measurement are in the range 6-7, which almost the same pH for every water samples. This condition describe that the water reach the quality standard criteria. Measurement of ph value can examined a foreign substance that was found in the water . Low ph or acid content will is corrosive , usually derived from chemicals are acidic. On the contrary , waters with high pH or is alkaline usually receive waste from exiles inorganic material like compound carbonate , bicarbonate , and hydroxide. Hence , water with a ph which is too high or too low can not support the life of the biota in the water, like some kind of fish.

Dissolved Oxygen (DO) in water samples are in range 7,32 – 8,12 mg/L. The value of DO met quality standard, the minimum 4 mg/L. The amount of dissolved oxygen content is indicated that the condition of river water being able to support life of the biota in water. The condition of dissolved oxygen are depended on the levels of temperature, salinity, chemical or biochemical material in the water, etc. Higher temperature, less concentration oxygen would be hold, more chemical or biochemical material in the water means less dissolved oxygen in the water. it is because organic materials in the water consume the oxygen, so the low DO indicates high consume of oxygen by the microorganisms.

Biochemical Oxygen Demand (BOD) and Chemical Oxygen demand (COD)

The test to find out the number of oxygen required are related to determine the number of oxidation of biochemistry. Pollution by materials organic can be examined through the BOD test. The results of a laboratory test of obtained the value of the total sample liter water meet quality standards that is below 3 mg/L. Range from 0,14 – 1,29 mg/L. This indicates that biochemical ingredients in water still meet the environment support the Jeneberang waters.

The value of COD of any of the water the results range between 0,27 – 3,54 mg/L, which all meet of quality standard that required the maximum value 25 mg/L. The river waters indicates that decomposition process material-material organic substances from entering the waters can run according to the ability of water. The value of COD and BOD in waters das jeneberang and reservoirs bili-bili is still support to the fish, and standards quality of raw water, as water designation Bili-bili reservoir for Gowa, the City of Makassar, and surrounding areas.

Table 5. Water Quality of Jeneberang Watershed and Bili-bili Reservoir.

No.		1	2	3	4	5	6	7	8	Quality standard
Sample water		**Point 1**	**Point 2**	**Point 3**	**Point 4**	**Point 5**	**Point 6**	**Point 7**	**Point 8**	
Parameter	**Unit**									
Physics										
Temperature		24^0C	22.7^0C	25.5^0C	26.1^0 C	23.5^0C	24.8^0C	26.1^0C	28.6^0C	
TDS	mg/L	36	27	32	55	30	19	56	42	1000
TSS	mg/L	3,3	12,9	20,8	107,9*	17	11,7	78,9*	7,2	50
Chemical										
pH		6	6	6,5	6	6	6	6	6	6,5-7,5
COD	mg/L	2,18	2,18	3,54	0,54	1,63	2,45	0,27	1,09	25

No.		1	2	3	4	5	6	7	8	Quality standard
Sample water		**Point 1**	**Point 2**	**Point 3**	**Point 4**	**Point 5**	**Point 6**	**Point 7**	**Point 8**	
Parameter	**Unit**									
BOD	mg/L	0,78	0,28	1,15	0,67	0,28	0,14	0,14	1,29	3
DO	mg/L	8,10	7,32	7,82	7,87	8,12	7,82	7,54	7,87	4
Nitrate (No3-)	mg/L	0,07	9,17	15,95*	8,49	7,81	9,17	0,07	0,07	10
Ammonia (NH3-N)	mg/L	0,010	0,011	0,021*	0,018	0,014	0,013	0,024*	0,021*	0,02
Phosphate (PO4-P)	mg/L	0,31*	0,26*	0,29*	0,28*	0,24*	0,15	0,33	0,04	0,2
Oil	mg/L	4*	1	3*	5*	3*	2*	3*	4*	1

(*) = Exceed of quality standard of Government Regulation No.82/2001.

Nitrate, Ammonia, Phosphate, and Oils.

The measurement of nitrate are considered as there are activity such as rice field and some plantation along the watershed .Nitrate constitutes one of the elements building blocks in fertilizers commonly used by the agricultural sector . But , in addition , in waters nitrate content can also be derived from input household wastes , waste from the rest of the livestock feed , the binding of nitrogen and free from air by microorganisms. The results of testing laboratory got that only one locations which have the womb nitrate is beyond of quality standard , where the point 3 (15,95 mg / L). Point 3 as a point of meeting sub-das happened indicates that the accumulation of nitrogen content in the form of nitrate from activity along the river , namely settlement and tourism of both parts of the river.

Nearly the same nitrate , ammonia is the polluter containing nitrogen , generally of organic matter that changed by bacteria to ammonia. The results of testing in the laboratory indicate the whole water sample met the quality standard, at the point of 1 , Point 2 , Point 4 , Point 5 , and a Point 6 that is below 0,02 mg /L .On three other rally point , the value of the ammonia is slightly above of quality standard , namely 0,021 mg / L in Point 3 at the meeting of the two sub-watershed that unite rivers which are after settlement areas , in a Point 7 (0,024 mg / L) closer to before entering reservoir waters , and in a Point 8 (0,021 mg / l) in waters reservoir .The ammonia slightly above of quality standard in a Point 3 indicated a result from household waste containing organic matter .The pollutant is derived from food waste that are wet and the waste containing detergents.

From the observation, known there are a heap waste disposal, that be the not-authorized by people of in settlement or arround. In Point 7 , the cause of the ammonia on water indicated derived from activity in the restaurant on the edge of waters , potential waste from metabolism , farming fertilizer around waters , and other would be bad impact to water quality. One of the things that including of worrying and need management content is found ammonia slightly over of quality standard in waters reservoir to raw water at Point 8. .It will likely to risk on the quality of drinking water .On that location weer found stench, a less carry happened chemical reaction indicates that produces ammonia . If it continues, in addition to cause to drop the quality of drinking water, it also will have an impact on the fish biota in water.

Phosphat laboratory test aims to know the polluter factor derived from emissions cleaning materials like soaps and detergents that containing

phosphat . Usually , can be derived from industrial activity both class large industries nor the level of household , and can also be derived from the activity of households. Phospohat content on the water can trigger a growing of plants that can disturb the way of a current or stream of water in the river. Besides , if this occurred would impact on oxygen consumption by the vegetation thus reducing the availability of levels of oxygen dissolved in water. Measurement result in samples of water obtained value in the range of 0,041 – 0,309 mg/L. From these results known that concentration phosphat value that meets quality standard only on the point of 6 and point 8. Point 6 is point that is after the activity of tourism , namely Malino tourism area, while Point 8, located in water reservoir to be allocated for supplying it raw water for drinking water.

In other points, the value exceed of quality standard, of which there are settlement activity, having ducts actually to the waste, as in Point 2. In addition, as in Point 7, there were restaurants area, indicated to exert an influence upon phosphat content by the activity. there were 32 restaurants were found. From the observation in the field, it is evident that public facilities, bathroom and the toilet drain waste directly on the river water to reservoir.

Oil content fat in the water shown that reached the entire sample value exceed of quality standard, with 2 mg/L. Among Eight water samples, oil content fat meet of quality standard only in in Point 2 (1 mg / L). Oil contained in water will obstruct oxidizing process on aerobic condition, because it is not dissolved with water or difficult outlined bacteria. Fatty oil generally will form a layer on the surface of water, or can also form mud and settles. Substances can be derived from captives containing the remains oil , as activity laundering, households in tourism area , restaurants area , and vehicle laundering which is usually done by the community in the edge Bili-bili reservoir.

Pollution Index (PI)

Pollution index describe the suggestion of water quality status to determine the action or policy of the river's or water management. Water quality status is indicate the pollution level that showed the condition of the water in sampling time, as compared to the quality standard. The result of Pollution Index analysis show that all the waters samples are in moderately polluted classification.

Table 5. Pollution Index of Jeneberang Watershed and Bili-bili Reservoir.

Sample	Pollution Index	Status
Point I	3,754	Moderately Polluted
Point 2	1,157	Moderately Polluted
Point 3	2,499	Moderately Polluted
Point 4	3,298	Moderately Polluted
Point 5	3,750	Moderately Polluted
Point 6	2,275	Moderately Polluted
Point 7	2,475	Moderately Polluted
Point 8	2,870	Moderately Polluted

Pollution index score are range in 1,157 – 3,754 which categorized as moderate polluted. The causal factor in Point 1 to be moderately polluted is Phosphate and Oil content that exceed the quality standard. Point 1 is located in spring area, the Phosphate and Oil content are predicted come from human activity on the higher elevation, for example agriculture and small livestock, as

met in the location when some cows were on the edge or in the river. Point 2 is the lowest PI score (1,157) polluted because the Phosphate content a little bit exceed the quality standard. Phosphate could be came from the settlement area activities. Point 3, are moderately polluted because of three factors, Nitrate, Phosphate, and Oil content. This point is the meet point of two sub-watershed that derive from river that accross settlement area and river that accross agriculture. Nitrate and Phosphate are predicted came from agriculture activities which used fertilizer and from settlement area which might bring the waste to the rier flow. Phosphate also might predicted come from agriculture acitivities and household actifities from the the detergent in loundry.

Point 4 is moderately polluted because of higher TSS and also Phosphate and Oil content that exceed the quality standard . the high score of TSS are happened because of sand quarrying activities along the river side. It also looked coherently from the colour of the water. Water in this area was turbid. Point 5 are being moderately polluted also because of Phosphate and Oil content were exceed the quality standard. Furthermore, Point 5 as water spring is also moderately polluted, which caused by Phosphate and Oil content that exceed the quality standard. It happened also because on the higher elevation, some people do washing activities.

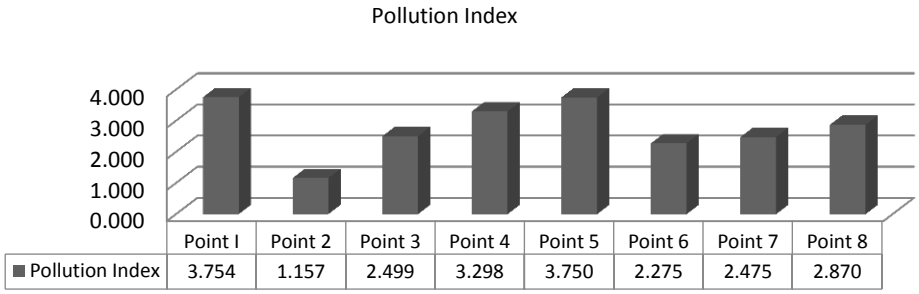

Figure 1. Pollution Index

Next, Point 6, being moderately polluted because of Oil content. Point 6 is located near tourism activities in Malino. Oil content indicate that the tourisme activities such as the restaurant and other its household waste obtain the over level of oil. Whereas, Point 7 are moderately polluted because of TSS and Oil content. TSS is affected by the errosion in the wall of reservoir beside the material that derive by river flow. For Oil content, it is influenced by tourism activities arround the water on this resevoir which had many restaurant, whose efflorescent the waste to the water. The last, Point 8, are moderately polluted because of Oil content factor. This point is the last point in reservoir before the water being treated as drink water. this little bit exceeding quality standard need a good treatment in order to become good quality to be consumed.

Spatial Distribution

The activities along the Jeneberang River are settlements, tourism, agriculture, and sand quarry. Points 1, 2, and 6 in Tinggimoncong. The land use in this area are settlements, agricultures and tourism. Total area of agricultural or wetland in this area is 1.353 hectare which consists of 939 hectares for irrigation, and 414 hectares for rain fed. While 14.287 hectares for area which not agricultural or wetland (BPS Statistics of Gowa Regency, 2015). Tourism area in Malino, The Capital City District of Tinggimoncong.

The Communities in Tinggimoncong largely worked as farmers and managers of tourism areas.

Point 5 is in Parigi, Gowa. The land use in this area is settlements, agriculture, tourism and sand quarry. The total area of agricultural land in this area is 1.256 hectares consisting of 806 hectares for irrigation and 450 hectares for rain fed. While 13.276 hectares for area not agricultural or wetland (BPS Statistics of Gowa Regency, 2015). Tourism area in the Majannang, The Capital District of Parigi. Sand mining activities are located on the main river flow of Jeneberang. The Communities in the Parigi largely worked as farmers and sand miners.

Point 7, 4, and 3 are located in Parangloe. Point 3 is located at the sub watershed merges area of Malino and Lengkese. Point 4 and 7 are located on the main river flow of Jeneberang before Bili-Bili Reservoir. Landuse in this area are settlement, agriculture, tourism, and sand quarry. Total area of agricultural land in this area is 1.029 hectares, consisting of 446 hectares for irrigation, and 583 hectares for rain fed. While 22.162 hectares for area not agricultural or wetland area (BPS Statistics of Gowa Regency, 2015). This area is dominated by the sand quarry activities. So that the communities in the Parangloe largely worked as farmers and sand miners. Point 8 is on the Bili-Bili Reservoir, located in the middle part of Jeneberang River, Parangloe. Bili-Bili Reservoir has of 1.728 kilometers squared area. This reservoir serves as tourist destination too. So, there are many tourism facilities around the reservoir such as restaurants and lodgment. This reservoir is also used by the community for daily activities such as fishing, fishpond, and washing.

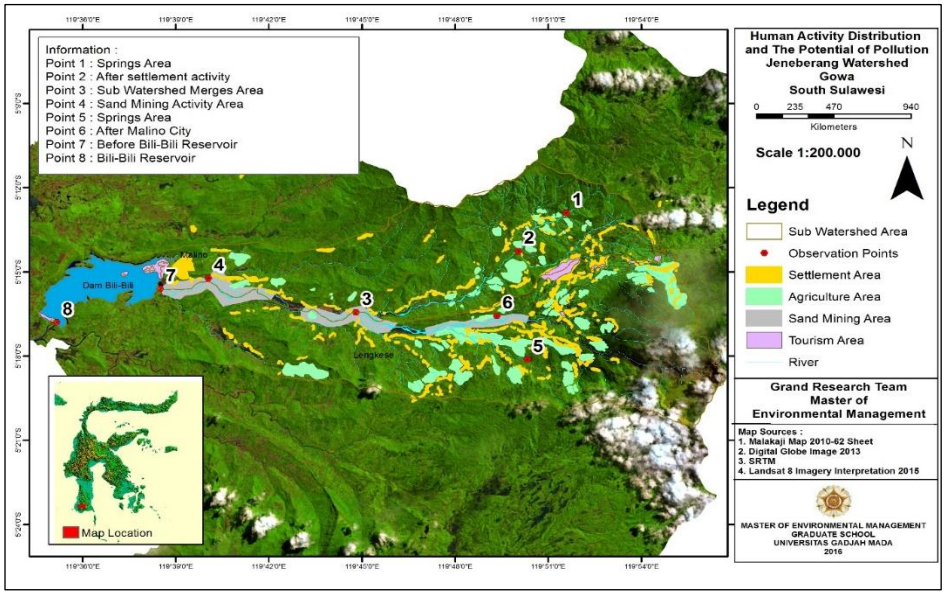

Figure 3. Map of Human Activities Distribution

CONCLUSION

Water quality in Bili-bili reservoir were moderately polluted status. This study need the description holistically as a watershed system. Bili-Bili reservoir is a part of Jeneberang Watershed. Jeneberang river are also indicate the pollution also happened, which caused by some activities were potentially contaminate the water. There are some parameters exceed the quality standard

of Government Regulation Number 82/2001 for water class II, such as Nitrate, Phosphate, TSS, Ammonia, and Oil Content.

Water pollution based on test and laboratory, and spatial analysis showed that the causal factor of this pollution are the impact of activities in settlement area, agriculture, tourism, and sand quarrying.

Acknowlegdement

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