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by Parida Angriani

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MANAGEMENT OF KUIN RIVER USING THE ECO-HYDRAULIC APPROACH

Parida Angriani[1], Akhmad Munaya Rahman[2], Karunia Puji Hastuti[3]

[1]*Department of Geography Education, Faculty of Teacher Training and Education, Lambung Mangkurat University, Banjarmasin, Indonesia*
[2]*Department of Geography Education, Faculty of Teacher Training and Education, Lambung Mangkurat University, Banjarmasin, Indonesia*
[3]*Department of Geography Education, Faculty of Teacher Training and Education, Lambung Mangkurat University, Banjarmasin, Indonesia*

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ABSTRAK

Pengelolaan sungai dengan pendekatan eko-hidraulik bertujuan untuk melestarikan komponen ekologi di lingkungan sungai melalui rekayasa hidraulik. Penelitian ini bertujuan untuk mengidentifikasi kondisi eksisting di perbatasan Sungai Kuin, menganalisis hubungan dan pengaruh aktivitas masyarakat di bantaran Sungai Kuin terhadap kualitas air Sungai Kuin, dan mempelajari pola perkembangan sungai dengan konsep eko-hidraulik di Sungai Kuin. Sungai. Pengumpulan data dilakukan berdasarkan hasil survei lapangan dan uji laboratorium untuk air dan tanah. Hasil penelitian menunjukkan bahwa kondisi bantaran sungai Sungai Kuin saat ini belum memenuhi fungsinya sebagai penyangga antara sungai dan daratan, karena banyaknya pemukiman masyarakat dan bukan vegetasi yang berfungsi sebagai pelindung sungai. Sungai Kuin tercemar karena beberapa indikator ekologi seperti pH, Fe, BOD, dan COD telah melebihi batas maksimum yang diperbolehkan. Hal ini terjadi karena aktivitas sosial dan perkembangan di sepanjang sungai yang berdampak pada aspek biotik dan abiotik sungai. Jenis tanah di bantaran Sungai Kuin adalah lanau bercampur tanah liat dengan plastisitas sedang sampai tinggi. Berdasarkan kondisi tersebut, terdapat asumsi bahwa tebing di tepian Sungai Kuin berpotensi longsor. Oleh karena itu, direkomendasikan pola pengembangan perlindungan ing dengan menggunakan komponen vegetasi tepi sungai.

ABSTRACT

River management using the eco-hydraulic approach is aimed at preserving the ological components in the river environment through hydraulic engineering. This study aims to identify the existing conditions on Kuin River border, analyze the relationship and influence of community activities on the banks of Kuin River on the water quality of Kuin River, and study the river development pattern with the concept of eco-hydraulic on Kuin River. ata were collected based on the results of field surveys and laboratory tests for water and soil. The results showed that the current condition of the riverbank of Kuin River has not fulfilled its function as a buffer space between the river and the mainland, due to the large number of community settlements rather than vegetation that functions to protect the river. Kuin River is polluted because several ecological indicators such as pH, Fe, BOD, and COD have exceeded the maximum allowable limits. This occurs due to social activities and development along the river, which have an impact on biotic and abiotic aspects of the river. The type of soil on the banks of the Kuin River is silt mixed with clay with moderate to high plasticity. Based on this condition, there is an assumption that the cliffs on the banks of Kuin River have the potential for landslides. Therefore, a pattern for developing cliff protection using riverbank vegetation components is recommended.

[1] Parida Angriani
E-mail addresses: parida.angriani@ulm.ac.id

INTRODUCTION

Increasing the use of natural resources without taking into account the ability of the environment will cause various problems. One of the environmental problems in Indonesia is the decline in the function of watershed ecosystems. This ecosystem function is very important for the availability of water resources. However, this function decreases due to human activities. Based on data from the Ministry of Environment and Forestry in 2017, Indonesia has 2,145 critical watersheds that must be restored immediately and 108 watersheds are priority. The criteria for determining critical watersheds are derived from the low percentage of land cover, high annual erosion rates, the magnitude of the ratio of maximum river discharge and minimum discharge, and excessive sediment load (Suripin, 2002).

This critical watershed problem requires proper river management, so that the impact of environmental damage on human life can be minimized. Excessive water volume or large discharge during the rainy season causes flooding or overflowing of river water due to high rainfall and results in surface water (run off). Various efforts were made to control floods. Specifically, flood control efforts are carried out by two methods, namely by using structural method and non-structural method (Kodoatie & Sugianto, 2002; Sebastian, 2008; Wigati, Maddeppungeng, & Pratiwi, 2017).

Structural flood control is in principle carried out by building structures or water structures that can increase the flow capacity of a river cross section or reduce the flowing flood discharge (Santoso, 2016). River management using this method is common in Indonesia. Meanwhile, river management and flood prevention in a non-structural manner are carried out by arranging riverbanks which are used as inundation areas. This concept is carried out by integrating the ecological and hydraulic components of the river. The ecological component on the riverbank can be used as a hydraulic retention component that holds water flow, resulting in flood immersion on the riverbank. With a puddle on the riverbank, the ecological quality of the river can be maintained (Pertiwi, Sapei, Purwanto, & Astika, 2011; Rosyadie, 2013).

One of the rivers in the city of Banjarmasin that also requires special attention in its management besides Barito River and the Martapura River is Kuin River. Along this river, there is a residential area known as Kampung Kuin. But along with its development, this residential area became quite dense and many buildings were built right on either side of the river body. Increasing economic development activities, changes in land use and increased population growth have resulted in high regional pressure on the Kuin River environment (Angriani, Sumarmi, Ruja, & Bachri, 2018).

These changes will disturb the balance of the river and lead to unpredictable instability of the river. Regarding efforts to repair and restore river functions, the concept of pure hydraulic development cannot be used alone, because it does not consider the ecological aspects and impacts that will occur after development (Maryono, 2004; Mulet et al., 2016; Ulmi & Amal, 2017).

Repair and restoration of river functions using pure hydraulic concepts usually ignores ecological components such as vegetation in the river in making the river cross section and tends to make the river bed profile straight (regular). Whereas in the understanding of ecohydraulics, the longitudinal and transverse profiles of the river contain complete hydraulic physical components, such as riverbeds (sediments) and riverbanks, as well as the vegetation and animals (Bustos, Alfredsen, Fjeldstad, & Ottosson, 2019; Entwistle, Heritage, & Milan, 2019) living around them. In addition, it is also necessary to show the chemical components of river water (Maryono, 2004). The purpose of this research is to identify the existing conditions on the banks of Kuin River, to analyze the relationship and influence of community activities by the banks of Kuin River on the water quality of the river and to study the development pattern of the river using the eco-hydraulic concept.

METHODS

This study is a survey aiming to describe the situation that existed at the time the research was carried out and examine the cause and effect through identification of the existing symptoms. The location of the study is the Barito watershed system. Administratively, Kuin River is located between two sub-districts, namely North Banjarmasin District and West Banjarmasin District. This river passes through three sub-districts, namely North Kuin Village, Kuin Cerucuk Village and South Kuin Village. The location selection was based on the consideration that Kampung Kuin had become increasingly congested and many buildings were built right on either side of the river body. The study was conducted in November 2019 - April 2020.

Data were collected through field measurements. The location of data collection is determined based on river location data along ± 3909 m with a width ranging from 7-61 m (SDAD Kota Banjarmasin, 2015). The depth of the river was measured using an echo sounder, while the water velocity was measured using a current meter three times at each location. Land use data on riverbanks were collected by observing and recording land use at each point on the left and right of the river.

Data on community activities on the banks of Kuin River were collected by making direct observations and distributing questionnaires to respondents. Respondents were determined based on the incidental sampling method, namely the land manager or land owner along the river that was met during the research activity. Meanwhile, to see the quality of river water, data was collected by taking water samples at five points on the left and right of the river, starting from the mouth of Kuin River towards Barito River and ending at Martapura River. The water sample is then tested physically and chemically in the laboratory. The same is done with soil samples.

The data analysis used to answer the first research question was descriptive analysis, which provides a detailed description of the existing conditions of Kuin River Border. Meanwhile, correlational analysis was used to answer the second research question, namely to analyze the effect of community activities around Kuin Riverbank on the water quality of the river. For the analysis of river water quality itself based on the results of laboratory tests. Likewise with soil samples, the data analysis used laboratory tests. The third research question was answered using descriptive data analysis, based on the results of the answers to the previous problems.

RESULTS AND DISCUSSION

A. Existing Condition of Kuin River Border

1. Characteristics of Kuin River

Kuin River is one of the Barito tributaries. This river empties directly into Barito River and forms a link between Barito River and Martapura River. Kuin River is included in the category of medium-sized rivers with a length of about 3,909 m and a width of about 7-61 m (Figure 1).

Figure 1. Map of Rivers in North Banjarmasin District

Along Kuin River, the riverbanks are almost non-existent because they have been converted into land for buildings, which are generally residential areas. The houses that stand on a river body have a length that extends to the middle of the river. The average length of the buildings on Kuin River ranges from 9-10 m. If it is assumed that on the left and right along the river which has a width of 40 m, there are houses of the same length, then the river space is only ± 20 m. This proves that there is almost no bank along Kuin River and the river has become narrower by the presence of buildings on the river body (Figure 2).

Figure 2 Condition of Kuin Riverbanks (source: Field Documentation, 2019)

2. Water Quality of Kuin River

River quality is influenced by several factors, including water discharge. Kuin River is a river that has a relatively small slope with a flow rate of around 0.74-1.45 m/s (DSDAD, 2015). This relatively small water discharge causes water conditions in the Kuin River to be relatively calm. This water discharge greatly affects the level of river erosion.

Apart from discharge, pollution levels also affect water quality. River water pollution can be caused by many things, such as industrial waste, oil spills, fertilizers or household waste. Based on this, the biggest source of pollutants comes from household waste, namely human waste (defecating directly into the river) or septic tanks made of wood so that they are inadequate so that human waste seeps into the river. The increase in *E. coli* bacteria contamination in rivers also occurs because there are still floating toilets used by the community along the riverbanks. The standard provision for *E. coli* bacteria is 100mpn/100mm, while the rivers in Banjarmasin including Kuin River are far above that and some even reach tens of thousands of mpn. The *E. coli* content that exceeds the quality standard threshold indicates unhygienic river water.

People's habit of throwing garbage into the river also contributes to the pollution of river water. When the tide is high, plastic waste will be carried away by water, and when the water recedes, the garbage will get stuck under residents' houses and will accumulate over time.

Apart from having an effect on water quality, plastic waste will also lead to faster silting of rivers.

To determine the quality of water in the Kuin River, samples were taken at 5 points. The water quality results were obtained from the UPTD health laboratory testing. The following is a table of chemical water quality data analysis.

Table 1. Chemical Test Results of Kuin River Water Samples

No.	Sample		pH	Iron (mg/l)	BOD (mg/l)	COD (mg/l)	Test Method
1.	Point 1	Right	6,40	0,65	15,30	34,00	Photometry
		Left	6,40	0,77	20,60	44,00	Photometry
2.	Point 2	Right	6,40	0,77	10,50	42,00	Photometry
		Left	6,40	0,80	26,50	59,00	Photometry
3.	Point 3	Right	6,40	0,70	25,30	59,00	Photometry
		Left	6,40	0,83	28,80	64,00	Photometry
4.	Point 4	Right	6,50	0,67	17,90	39,00	Photometry
		Left	6,50	0,54	16,10	35,00	Photometry
5.	Point 5	Right	6,30	0,16	23,80	53,00	Photometry
		Left	6,30	0,16	24,90	53,00	Photometry

Source: UPTD Health Laboratory of Banjarmasin City Health Department, 2020

The chemical parameters of river water quality are based on the Regulation of the Governor of South Kalimantan Number 5 of 2007 concerning the Allocation and Standard of River Water Quality. Based on these regulations the maximum pH level of river water is 6-9 and for Kuin River the pH level is still at the normal level, namely 6.4. Meanwhile, the maximum content of iron (Fe) based on the Regulation of the Governor of South Kalimantan is 0.3 mg/l and the iron (Fe) content of Kuin River at several points tends to exceed quality standards. A certain amount of Fe content is needed by living organisms, but if it is concentrated in large amounts it can cause toxic effects (Supriyantini & Endrawati, 2015). The high content of Fe in Kuin River is thought to be caused by the content of Fe which comes from several sources, namely apart from the soil also from human activities along the banks of Kuin River, namely the presence of household waste containing iron, industrial waste deposits and corrosion from water pipes containing ferrous metal carried by the river flow.

Apart from the pH value and iron content, the chemical quality index of Kuin River water can also be seen from the BOD and COD content values. Based on the Regulation of the Governor of South Kalimantan, the maximum BOD and COD content allowed are 12 mg/l and 100 mg/l, respectively. Based on Table 1, the BOD content of Kuin River has exceeded the permissible threshold, which is in the range of 15-28 mg/l, while the COD content is still at the permissible level, namely in the range of 34-64 mg/l. BOD and COD are needed as parameters for water quality standards because they are related to determining one of the water pollution

indexes. Its role as an estimator of organic matter pollution and its relation to decreasing dissolved oxygen content in waters. BOD and COD are not the main determinants in estimating the level of water pollution, but are equivalent to other key parameters related to estimating water pollution by certain activities (Atima, 2015).

3. Soil Quality on the banks of Kuin River

In general, soil quality is defined as the capacity of the soil to function in an ecosystem in relation to its carrying capacity for plants and animals, prevention of erosion and reduction of negative impacts on water and air resources (Karlen et al., 1997). Soil quality can be seen from 2 sides, namely as the inherent soil quality which is determined by the five soil-forming factors and dynamic soil quality, namely changes in soil function as a function of human use and management (Seybold et al., 1999).

Soil quality indicators really depend on the purpose of the evaluation. For the study of the ecohydraulics of Kuin River, the results of soil classification on the left and right banks of Kuin River were obtained from the results of examinations in the Soil Mechanics Laboratory of the ULM Faculty of Engineering. Table 2 below presents the results of the classification of the soils on the banks of Kuin River.

Table 2. Soil Classification of Kuin Riverbanks

No.	Soil Sample		Soil	Information
1.	Upstream	Point 3 on the right	High plasticity silt	MH Inorganic silt or fine diatomic sand, elastic silt
		Point 3 on the left	High plasticity silt	MH Inorganic silt or fine diatomic sand, elastic silt
2.	Middle of the river	Point 2 on the right	Medium to high plasticity clays	OH Organic clays with moderate to high plasticity
		Point 2 on the left	Medium to high plasticity clays	OH Organic clays with moderate to high plasticity
3.	Downstream	Point 1 on the right	Medium to high plasticity clays	OH Organic clays with moderate to high plasticity
		Point 1 on the left	Medium to high plasticity clays	OH Organic clays with moderate to high plasticity

Source: Lab Inspection Results. Soil Mechanics FT ULM, 2020

Based on Table 2, it can be seen that the type of soil on the banks of Kuin River is silt mixed with clay with moderate to high plasticity. In general, the greater the soil plasticity index, i.e. the greater the range of water content in the plastic area, the poorer the soil will be in terms of strength and will have greater swelling and shrinkage. By looking at the type of surface soil on the banks of Kuin River and the high plasticity index, the volume will increase in wet conditions and will shrink when in dry conditions. This property causes rapid damage to building construction.

4. Vegetation and Fauna of Kuin River

The types of vegetation and fauna along the banks of Kuin River are presented in Table 3 and Table 4

Table 3. Types of Vegetation on the banks of Kuin River

No.	Name of Plant	Information
1.	Rambai Padi	Exist
2.	Kasua stripes	Exist
2.	Acacia	Exist
3.	Betel nut	Exist

Source: Field Data, 2020

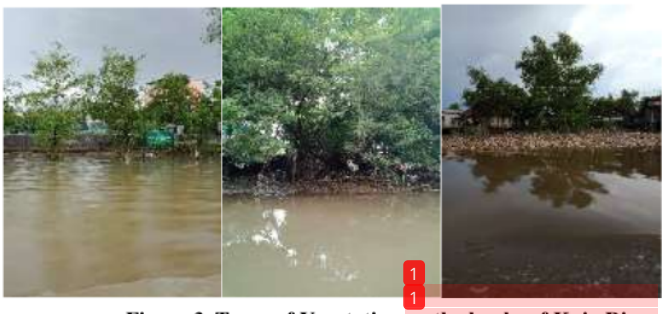

Figure 3. Types of Vegetation on the banks of Kuin River (source: Field Documentation, 2020)

Tabel 4. Types of Fauna on the banks of Kuin River

No.	Types of Fauna	Information
1.	Parrot Fish	Exist
2.	Puyau Fish	Exist
3.	Haruan Fish	Exist
4.	Sparrows	Exist
5.	Swallow	Exist

Source: Field Data, 2020

Based on Table 3 and Figure 3, the types of vegetation that exist on the banks of Kuin River are not natural vegetation that grows in that place, but vegetation that is intentionally planted with the aim of carrying out riverbank conservation. This occurs because along the riverbanks are densely populated with residential areas, causing natural vegetation that should have grown along the riverbanks to disappear because the place where it grows has changed its function to a place of residence. As for the types of fauna in Kuin River, based on Table 4, several types of river fish still exist even though they are increasingly difficult to find. This is a sign that the deteriorating quality of river water can cause loss of river biota.

5. Settlement Patterns of Kuin River Bank Community

In general, settlement patterns in the city of Banjarmasin are longitudinal (linear), namely along river channels and along roads. Likewise, the form of settlements in the study area, which extends along Kuin River and along the road. This pattern is formed because the existing culture in the community is related to the way of life, how to adapt to the environment,

and fulfill the needs that depend on the river (Buzarboruah, 2014; Ideham, Sjarifuddin, Anis, & Wajidi, 2015; Lambut, 2017). This settlement pattern is formed naturally and develops due to environmental conditions and community life activities that use the river as infrastructure for movement (Geonmiandari, Silas, & Supriharjo, 2010; Mentayani, 2016).

The residents' houses that are above the river were originally made in the form of floating houses or known as Lanting Houses. Meanwhile, the house on land, the orientation of the house is always facing the river in the form of a house on stilts (Dihiri, 2012; Rahmitiasari, Antariksa, & Sari, 2014). However, over time, this settlement turned into a fairly dense area. Many residential buildings are built on either side of the river body permanently/semi-permanently with the orientation of the houses mostly facing the road. The houses are built partly on the ground and partly above the river or jutting into the middle of the river body. The development of settlement areas along Kuin River can be seen in Figure 4.

a)  b) 

Figure 4. Development of Settlements along Kuin River (source: a. Depo Regional Archives of South Kalimantan Province, b. Field Documentation, 2019)

Most of the houses built along the Kuin River border are shaped like stilts. The choice to build a house on stilts is inseparable from the condition of the land in Banjarmasin, which is generally in the form of wetlands, such as swamps and very little dry land. If the building is not a house on stilts, which is a backfill above or on the side of a river, besides being prohibited (Banjarmasin City Regulation No.14 of 2009 on Stilt Houses) it also requires very high costs, and the risk of damage and failure due to river currents is quite large.

In addition, when viewed from the condition of the residents' houses, the survey results show that most of them look simple, made of ironwood construction with wooden walls. However, there are also those made of stucco cement walls which are semi-permanent. The construction of the stage with ironwood is a characteristic of houses on the riverbank. As for the size of the house, the average length ranges from 9-10 meters with a width ranging from 6-

7 meters. The condition of the houses of the residents on the banks of Kuin River can be seen in Figure 5 below.

Figure 5. The condition of the houses on the banks of Kuin River (source: Field Documentation, 2019)

6. Social Activities of Kuin River River Community

Kuin River has an important role for the people on its banks. They use the river for their daily needs, such as bathing, washing, defecating, watering plants, market places (floating market), and transportation. Meanwhile, for drinking and cooking purposes, the majority of people already use tap water, either by buying collectively through a water tank or by already having a PDAM channel. The following is a picture of river water utilization by the people on the banks of Kuin River.

Figure 6. Utilization of River Water for Daily Purposes (Source: Field Documentation, 2020)

Based on Figure 6, using river water for daily needs such as bathing or washing is something people usually do. This is because no matter how much they take water from the river, they don't have to worry about buying. If they use tap water, every month they have to set aside money for water bill payments. Tap water is only used for cooking and drinking purposes, or when river water feels brackish (a little salty). This situation occurs during the long dry season when sea water intrusion occurs. Table 5 presents data on community activities

on the banks of Kuin River related to river water utilization. The answers came from 51 respondents who live on the banks of Kuin River

Tabel 5. Community Utilization of Kuin River Water

No.	Question Items	Alternative Answers		
1.	Use of river water for daily needs	Never 13.72%	Sometimes 41.18%	Always 45.01%
		Tap water	Well water	River water
2.	Source of water for bathing	62.75%	0	37.25%
3.	Source of water for washing	62.75%	0	37.25%
4.	Source of water for drinking & cooking	100.00%	0	0

Source: Field Data, 2020

The direction of waste disposal into rivers has decreased. This is due to increased public awareness regarding waste management. The community realizes that if they throw garbage into the river, it will worsen the quality of river water. However, with regard to the place to defecate, what was observed was the construction of latrines/toilets that were attached to the house as in general, but long before that latrines were built in the form of floating latrines or on trunks (a bridge between residents' houses to the river) (Figure 7). As for the reservoir, the majority of the waste is dumped directly into the river. Table 6 presents data on community activities related to household waste management.

Figure 7. Condition of the toilets on the banks of Kuin River (source: Field Documentation, 2020)

Table 6. Household Waste Management for Riverbank Communities

No.	Question Items	Alternative Answers		
1.	Form of waste water disposal (toilet)	Septic tank 21,57 %	Filter pipe 11.76%	Straight to the river 66.67%
2.	Trash dump	Temporary dumpsite (TPS) 88,24 %	Personal trash can 5.88%	River 5,88 %

Source: Field Data, 2020

7. Ecohydraulics Study of Kuin River

The density of settlements along the Kuin River disrupted the natural function of the river. River preservation measures are carried out through conservation efforts with an

ecological approach. Restoring the function of the river, both ecological and cultural functions, is a program that must be carried out in an effort to conserve the Kuin River. This is because the existing functions are starting to fade with the times. The restoration of the river's ecological function is carried out by returning the banks as open spaces. This is intended to withstand the rate of erosion. Besides that, it is also meant to be a park for the surrounding community

One of the ways to restore the river's ecological function is through the application of the concept of ecohydraulics on one of the cliffs of Kuin River. Handling of floods with a concrete eco-hydraulic concept consists of: forest conservation, water conservation, land use arrangement, riverbank arrangement and erosion prevention (Boskalis et al., 2018; Maryono, 2007). The concept of eco-hydraulic also activates riverbank areas as flood retention (Bockelmann, Fenrich, Lin, & Falconer, 2004). As an ecological buffer, riverbanks are an important area for the sustainability of the river, a transitional area (ecotone) between the aquatic system and the terrestrial ecosystem (Onrizal, 2005). Riverbanks have important roles, including: providing a unique habitat for biota, regulating organic supply to the aquatic system (Bustos et al., 2019), as an indicator of hydroclimate, and having strong visual quality in creating colors, variations and a different image and creating a wilderness experience.

Bio-engineering can be carried out on the downstream cliffs of Kuin River which empties into Barito River or those at risk of potential landslides by combining bamboo and vetiver grass. River cliffs are a suitable habitat for bamboo plants. Bamboo is a group of grasses (Gramineae family), the stems are tubular, with joints as pipe dividers, having a special skin layer on the inside and outside of the stem. Meanwhile, vetiver grass is a plant that is very easy to grow in various levels of soil fertility, dry soil, and waterlogged soils. Vetiver grass is relatively easy to grow and its maintenance does not require special treatment. Vetiver grass roots grow dense and stick down (can reach ± 3 m into the soil), so that there is no competition for nutrients with other plants.

Bamboo and vetiver grass are planted on the downstream banks of Kuin River, then dry bamboo sticks are used to strengthen the cliffs, which are anchored vertically on cliff sites that are threatened with landslides or scouring. Bamboo stalks are installed horizontally and tied to vertical bamboo. Between the vertical bamboo rows are inserted tree branches (all kinds of twigs and branches). With this formed porous fins that can hold flood water and bind sediment. After sediment is formed, the vetiver grass planted will grow strong and its regular growth does not overlap and are linked so that it can accelerate the deposition process. By the time the

bamboo culms become brittle due to heat and time, the vetiver grass and new sediment on the river banks are stable enough and able to withstand scouring.

Empty stone pairs placed between the foot of the cliff and the riverbank are made to control erosion in the area. When the water level falls, the stone masonry can be planted with vetiver grass in between, this makes the empty stone pairs more stronger and tied to the cliff. In the direction of the flow that hits the river bank or when deflecting the water flow, bamboo is best planted, because this can minimize erosion due to flow velocity. Bio-engineering for the downstream cliffs of Kuin River can be seen in Figure 8.

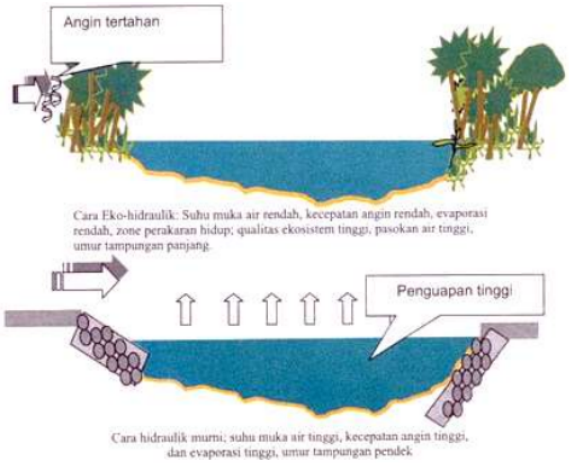

Figure 8. Bioengineering
(source: kampus teknik sipil.blogspot.com)

CONCLUSION

The current condition of the Kuin River banks has not fulfilled its function as a buffer space between the river and the mainland, due to the large number of community settlements rather than plants. Settlement patterns along the banks of Kuin River are developing rapidly with the direction towards the building, which is mostly facing the road and facing the river. This proves that there is a change in the view of the river in the current community along Kuin River. The river is seen as a back area, or simply as a "rear" activity site (for bathing, washing, and defecating purposes). This condition affects the Kuin River, especially on its water quality.

From laboratory test data, it can be seen that Kuin River has been polluted due to several ecological indicators such as pH, iron content (Fe), Biological Oxygen Demand (BOD), and Chemical Oxygen Demand (COD) exceeding the maximum allowable limits. Based on this, it can be argued that Kuin River has been polluted due to social activities and development along the river flow which have an impact on biotic and abiotic factors of Kuin River.

Based on the results of soil analysis on the banks of Kuin River, there is an assumption that the cliffs on the riverbank have the potential for landslides. Thus, it is recommended that the development pattern of cliff protection with the concept of eko hidraulik, namely using riverbank vegetation components such as bamboo and vetiver grass. This is done to utilize the river's potential in an optimal and sustainable manner.

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