# The Riparian Soil Compounds of the Upper Ranoyapo River, South Minahasa - North Sulawesi - Indonesia

*by* Henry Fonda Aritonang 7

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# The Riparian Soil Compounds of the Upper Ranoyapo River, South Minahasa - North Sulawesi - Indonesia

Ratna Siahaan[1,3,a)], Song Ai Nio[1,3], Henny Lieke Rampe[1], Henry F. Aritonang[2]

[1]*Biology Department, Faculty of Mathematics and Natural Sciences, University of Sam Ratulangi Manado-Indonesia*

[2]*Chemistry Department, Faculty of Mathematics and Natural Sciences, University of Sam Ratulangi Manado- Indonesia*

[3]*Univercity Centre of Excellence for Biotechnology and Conservation of Wallacea, University of Sam Ratulangi Manado-Indonesia*

[a)] corresponding author: ratnasiahaan@unsrat.ac.id

**Abstract.** Ranoyapo River is a main river of Ranoyapo Watershed. Soil stabilization is important issues related to landslide of soil riparian. The aim of this research was to analyze riparian soil compounds of the upper Ranoyapo River. The research stations were located at Kinamang Village, South Minahasa, North Sulawesi. The soil samples were collected manually from riparian zone. All composited samples were analyze using XRF spectrometer. The result showed that riparian soil contained several compounds i.e., $Fe_2O_3$, $SiO_2$, $Al_2O_3$, CaO, $K_2O$, MnO, $P_2O_5$, CuO, $Cr_2O_3$ and ZnO. The concentrations of $Fe_2O_3$ and ZnO are highest (37.59%) and lowest (0.054%), respectively. The river water and biological weathering are main factor to distribute and influence the mineral component of riparian soil. The riparian soils are from sedimentation of upland soils. This increases the heterogeneity of riparian soils. This heterogeneity could increase biodiversity of riparian vegetation due to heterogenous habitats and nutrients.

## INTRODUCTION

Ranoyapo River is a main river of Ranoyapo Watershed, South Minahasa, North Sulawesi. This river has many important functions and services. It becomes the main water source for agriculture irrigation and domestic purposes. The upper Ranoyapo River has ecological functions i.e., to conserve soil and water. These ecological functions are maintained by riparian vegetation. This vegetation is located in riparian area. The riparian area is at the edge of streams [1-4]. Riparian ecosystems are transitional ecosystems (ecotones) that lie between river and terrestrial/land aquatic ecosystems. The vegetation that grows in the riparian ecosystem is called riparian vegetation. The ecosystem of riparian has various types of plants that have adapted to live in that are often flooded by river water [5].

Riparian vegetation has diverse ecological functions including maintaining the river quality. Also, riparian vegetation can regulate water temperature [5-6], and control river bank erosion [7]. Riparian vegetation plays an important role in maintaining river fisheries productivity. Riparian vegetation can prevent sedimentation in rivers which is very beneficial for animals such as fish that prefer sandy riverbeds [7]. Riparian vegetation can also be a supplier of river litter (energy) which is indispensable for the productivity of river fisheries [8-9]. Riparian vegetation is also a terrestrial wildlife habitat [5], a place for animals to seek shelters, mate and spawn [5,7,10]. Riparian vegetation is an important habitat for diverse organisms [4,11]. The riparian ecosystem is a natural buffer located between land and river. This ecosystem should be well managed for water quality and biodiversity [12].

The riparian vegetation types in the upstream of Ranoyapo River can be grouped into two, namely agricultural plants and natural plants. Several important agricultural plants are planted by farmers, namely rice (*Oryza sativa*), coconut (*Cocos nucifera*), corn (*Zea mays*), banana (*Musa* spp.), and cocoa (*Theobroma cacao*). Natural riparian vegetation types are herbs, shrubs and trees. The natural riparian vegetation were *Piper aduncum* and *Ficus* sp [13].

However, riparian is facing serious threats derived from human activities, which have led to degradation of ecosystem. Soil of riparian has important role in maintaining river quality by purification materials from upland before entering the river body. This research aimed to analyze the soil composition of upper Ranoyapo River, South Minahasa - North Sulawesi.

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## METHODS

Survey research was conducted at three stations at Kinamang Village, South Minahasa, North Sulawesi. The locations were chosen by purposed-random sampling method. All sites were located at riparian zone of headwater of Ranoyapo River. The bulk surface soils were collected manually from riparian zone. Three replications were conducted from each station. The soil samples were composite samples. After sample drying, crushing, and sieving, all samples were analyzed by X-Ray Fluorescence (XRF) Spectrophotometer.

## RESULTS AND DISCUSSIONS

The land use of riparian zone were cocoa plantation and secondary forest. Riparian vegetation habitus are herbs, shrubs, climbers, and trees from diverse species (Fig. 1). Based on total riparian cover, cover structure, cover quality, river channel naturalness, and connectivity riparian to terrestrial forest, quality of riparian habitat could be categorized into good level. Some of vegetation in riparian zone of upper Ranoyapo River such as *Ficus minahassae, Ficus septica*, *Ficus aurita*, *Piper aduncum*, *Sphagneticola trilobata, Hyptis capitata, Begonia, Elatostema*, and ferns.

**FIGURE 1**. Habitus of riparian vegetation of upper Ranoyapo River are herbs, shrubs, climbers and trees

The result showed that $Fe_2O_3$ and ZnO is the highest and lowest concentration, 37.59% and 0.054% respectively (Table 1). The presence of those oxide minerals in riparian soil is the natural condition. Indonesia has abundant natural resources include raw mineral. Among the mineral materials there are which is classified as an oxide mineral such as $SiO_2$, ZnO, and $Al_2O_3$[14]. The composition of soil riparian is from stream-deposited sedimentation. Sediment deposition to riparian zone periodically by streams during floods is accompanied by the flood of organic materials from riparian zones by river water. The riparian soil and plant are strongly influenced by environmental factors, such as hydrological processes, topographic feature, and ecological conditions of river system. All these factors will give impact to riparian soils [4]. The heterogenous soil composition will increase plant diversity in riparian zones. The diverse microhabitat will support the seeds of riparian vegetation to germinate and to grow. The soil composition are results from combination of water fluctuation [4]. The fluctuation of water debit in dry and rain season will impact to soil composition. The water dynamic of the river will impact to distribution of sediment in riparian zone. The lateral water movement from upland to the river also affect sediment and minerals in riparian due to sedimentation.

Soil compounds in riparian zone is deposited from upland before enter Ranoyapo River. The concentration of these compounds in riparian soil are influenced by several factors. The main source of cations is natural geology and mineral weathering include biological weathering process [3]. Biological weathering or bioerosion of rocks is caused by activities of organisms such as bacteria, lichens, fungi and roots of vegetation [15-16].

The highest concentration of $SiO_2$ due to its abundance in sand [17]. Silicon dioxide plays important role in productivity of aquatic ecosystems [18]. Minerals include calcium (Ca) and potassium (K) are important plant nutrients. The presence of these minerals indicates soil fertility [3]. This soil fertility supports biodiversity of riparian vegetation. This condition caused the high biodiversity of riparian [1,2]. Biodiversity of riparian vegetation of Suhuyon River, a tributary river of Ranoyapo Watershed, was categorized into moderate class 119]. This moderate class due to human activities. The diversity index is strongly determined by species richness and individual abundance of species. The land conversion of riparian forest to agricultural land and logging trees are main factors in declining riparian vegetation biodiversity.

**TABLE 1.** Riparian soil compounds of the upper Ranoyapo River

| Compound | Concentration (%) | | | |
|---|---|---|---|---|
| | average | SD | min | max |
| $Fe_2O_3$ | 37.59 | 1.97 | 33.8 | 40 |
| $SiO_2$ | 35.3 | 2.29 | 30.1 | 37.7 |
| $Al_2O_3$ | 11.73 | 1.07 | 9.6 | 13 |
| CaO | 9.397 | 2.902 | 6.78 | 16.2 |
| $K_2O$ | 0.94 | 0.46 | 0 | 1.5 |
| MnO | 0.894 | 0.251 | 0.68 | 1.5 |
| $P_2O_5$ | 0.74 | 0.363 | 0 | 1.4 |
| CuO | 0.187 | 0.025 | 0.15 | 0.24 |
| $Cr_2O_3$ | 0.0813 | 0.005 | 0.075 | 0.089 |
| ZnO | 0.054 | 0.021 | 0.03 | 0.09 |

Phosphorous (P) was present in low concentration. The concentration of P is influenced by nutrient transport from upland and rock weathering. The amount of P in riparian soils is strongly influenced by environment factors such as soil organic matter, pH, and Fe and Al [20]. Phosphorous together with other soil properties as soil moisture, carbon, and nitrogen are important for conducting ecological processes, including water purification [20]. The riparian vegetation plays important role in trapping and filtering nutrients from upland to riparian zone. In the future, the increasing of P inputs from upland and defragmentation of riparian vegetation could increase the P concentration in riparian soil.

The concentrations of MnO, $Al_2O_3$ and $Fe_2O_3$ found in the soil and water vary from site to site and are largely dependent on the surrounding anthropogenic activities as well as the natural geology. Geologic factors such as bedrock type can influence soil of riparian [21].

The riparian soil of upper Ranoyapo River has oxide minerals. These reserve minerals are easily weathered into soils. The reserve minerals can improve fertility of soil because soil has available nutrient sources [22]. This condition can support diversity of vegetation riparian. Although riparian soil can support biodiversity of riparian vegetation, we have to consider of human activities in Ranoyapo Watershed. The increase of human activities such as land conversion, agricultural activities and tree logging can give negative impact to diversity of riparian vegetation of upper Ranoyapo River. This could be serious threats due to upper has ecological function as conservation area for water and soil. The addition of minerals and nutrients from human activities, such phosphorous in soil from fertilizer, will affect water quality.

Riparian vegetation can regulate nutrients from upland before enter the water bodies. The loss of vegetation can increase nutrients in water including natural nutrients due to weathering process. The defragmentation of riparian vegetation could affect the water quality of Ranoyapo River. This condition will reduce the capacity of riparian vegetation to manage water quality. The soil chemical properties are strongly relation to tree cover, tree height, and shrub height [20]. The extensive-rooted systems vegetation has bigger ability to absorb minerals or nutrient [23] from terrestrial to the river. This indicates that conservation effort to manage water quality of Riparian River could be achieved if conservation of riparian is also carried out. Although, ecause of human pressure, it is not easy to design a sufficient buffer width of upper Ranoyapo River.

## CONCLUSION

The riparian soil of upper Ranoyapo River has several compounds i.e., $Fe_2O_3$, $SiO_2$, $Al_2O_3$, CaO, $K_2O$, MnO, $P_2O_5$,

CuO, $Cr_2O_3$ and ZnO. The concentrations of $Fe_2O_3$ and ZnO are highest (37.59%) and lowest (0.054%), respectively. The source of these cations are water sedimentation and rock weathering. Riparian soils are strongly influenced by river water and also by organic materials from riparian vegetation. The heterogenous soil composition increase plant diversity in riparian zones.

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