Leaflet No. 9/2017

The Republic of the Union of Myanmar

Ministry of Natural Resources and Environmental Conservation

Forest Department

Assessment on the Water Quality under Different Land Covers in Inlay Watershed Areas

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December, 2017

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အင်းလေးကန်ရေဝေရေလဲဒေသအတွင်း မြေအသုံးချမှု ပုံစံအမျိုးမျိုးတို့ကြောင့် ရေဝေရေလဲဒေသ အတွင်းရှိ ရေထွက်များနှင့် ချောင်းများ၏ ရေအရည်အသွေးအပေါ် သက်ရောက်မှုများကို ဆန်းစစ်လေ့လာခြင်း

မေသဇင်ဖူး ၊ ဒေါက်တာစံသွင် ၊ ဒေါက်တာငြိမ်းချမ်း
သစ်တောနှင့်ပတ်ဝန်းကျင်ဆိုင်ရာတက္ကသိုလ်၊ ရေဆင်း

စာတမ်းအကျဉ်း

စာတမ်း၏အဓိကရည်ရွယ်ချက်မှာ သစ်တောပြုန်းတီးခြင်း၊ သစ်တောအတန်းအစား ကျဆင်းခြင်း၊ ရွှေ့ပြောင်းတောင်ယာစနစ်များနှင့် မြေအသုံးချမှုပုံစံ အမျိုးမျိုးတို့ကြောင့် အင်းလေးကန်ရေဝေရေလဲ ဒေသအတွင်းစီးဆင်းသော မြစ်ချောင်းများ၊ ရေထွက်များ၏ ရေအရည်အသွေး အပေါ်သက်ရောက်မှုများကို ဆန်းစစ်လေ့လာရန်ဖြစ်ပြီး အင်းလေးကန် ရေဝေရေလဲဒေသစီမံအုပ်ချုပ်မှုကို အထောက်အကူပြုနိုင်ရန် ဖြစ်ပါသည်။ ထိုသို့လေ့လာနိုင်ရန် မြေအသုံးချမှုပုံစံ အမျိုးမျိုးရှိသည့်အနက်မှ သစ်တောဖုံးလွှမ်းမှု ကောင်းသောမြေ၊ သစ်တော အတန်းစား ကျဆင်းသောမြေနှင့် စိုက်ပျိုးမြေအနီးရှိ မြစ်ချောင်းများ၊ ရေထွက်များမှ ရေအရည်အသွေးဆိုင်ရာ အချက်အလက်များကို လစဉ် ကောက်ယူခဲ့ပါသည်။ ထို့နောက် ရေထု၏ဓာတုရူပဆိုင်ရာ အရည်အသွေးများဖြစ်သော ရေ၏ အပူချိန်၊ ထုံးဓာတ်ပျယ်နိုင်စွမ်း၊ ချဉ်ငန်ဓာတ်၊ ရေ၏လျှပ်ကူးနိုင်မှု၊ ရေတွင်အညစ်အကြေးများ ပါဝင်နေမှု၊ ရေတွင် အောက်စီဂျင် ပါဝင်မှု ၊ရေ၏အရောင် စသည်တို့ကို ဓာတ်ခွဲခန်းတွင် ဆန်းစစ်လေ့လာခဲ့ရာ ဆန်းစစ်မှုအရ သစ်တောဖုံးလွှမ်းမှု ကောင်းသောနေရာနှင့် သစ်တောအတန်းစား ကျဆင်းသောနေရာများတွင် ရေအရည်အသွေး များစွာခြားနားခြင်း မရှိသော်လည်း စိုက်ပျိုးမြေဖုံးလွှမ်းမှု များသော နေရာများတွင်ရေ၏ ညစ်ညမ်းမှု၊ ထုံးဓာတ်ပျယ်နိုင်စွမ်း နှင့် ရေ၏အရောင်တို့တွင် အခြားသော မြေအသုံးချမှုများထက်ညစ်ညမ်း နေသည်ကိုတွေ့ရှိ ရပါသည်။ ထို့နောက် ရေ၏ချဉ်ငန်ဓာတ် ရလဒ်များအရ လအလိုက်ကွဲလွဲမှုရှိသော်လည်း မြေဖုံးလွှမ်းမှုပုံစံ အမျိုးမျိုးတွင်ကွဲလွဲမှု မရှိသည်ကို တွေ့ရှိရပါသည်။ အောက်စီဂျင် ပါဝင်မှုရလဒ်များအရ လအလိုက် သော်လည်း ကောင်း၊ မြေဖုံးလွှမ်းမှုပုံစံ အမျိုးမျိုးတွင် သော်လည်းကောင်း ကွဲလွဲမှုရှိသည်ကို တွေ့ရှိရပါသည်။ ရေ၏လျှပ်ကူးနိုင်မှုကို ဆန်းစစ်ရာတွင် လအလိုက်သာမက မြေဖုံးလွှမ်းမှု အမျိုးမျိုးတွင်လည်း ကွဲလွဲမှုရှိသည်ကို တွေ့ရှိရပါသည်။ သစ်တောဖုံးလွှမ်းမှုရှိသည့် မြေမှရေနမူနာများ၏ အပူချိန် သည် အခြားမြေများထက် ပိုမိုလျော့နည်းကြောင်း တွေ့ရှိရပါသည်။ ခြုံငုံသုံးသပ်ရသော် သစ်တောဖုံးလွှမ်းမှု ကောင်းသောမြေနှင့် သစ်တောအတန်းအစားကျသော မြေမှရေနမူနာ များ၏ ရလဒ်များသည် သိသိသာသာ ကွဲလွဲမှုမရှိသော်လည်း စိုက်ပျိုးမြေမှ ရေနမူနာများနှင့် ကွဲလွဲမှုရှိကြောင်း တွေ့ရှိ ရပါသည်။ ထို့အပြင် မြေအသုံးချမှုပုံစံအမျိုးမျိုးနှင့် ရေအရည်အသွေး၊ ရေစီးဆင်းမှု ပမာဏ တို့၏ ဆက်စပ် နေမှုများကို အင်းလေးကန်အတွင်း စီးဝင်သောမြစ်ချောင်း များတွင် ဆန်းစစ် လေ့လာရန်လည်း လိုအပ်ပါသည်။

Assessment on the Water Quality under Different Land Covers in Inlay Watershed Areas

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Abstract

This paper presents the assessment of hydrological characteristics under different land covers for the contribution towards watershed ecosystem management in Inlay watershed areas. For this purpose, time series and point data were collected from the headwater sources under three different land covers such as forested, degraded and agricultural areas. The physio-chemical quality of water is assessed on various parameters such as water temperature, pH, conductivity, dissolved oxygen, alkalinity, turbidity and color. According to the results, there observed significant difference in temperature and alkalinity between three land covers. Water samples from agricultural land have low alkalinity than forested and degraded lands. In the case of temperature, the water samples from the forested sites are relatively lower than degraded and agricultural water samples. The pH value of water samples is significantly different in monthly but not spatially. Moreover, significant difference in conductivity of water samples was observed both monthly and spatially among the land covers. According to the results from dissolved oxygen, there is significantly different between different land covers but it also varied monthly. Generally, the results from this study show no significant difference between waters from forest and degraded area but significant difference between agricultural and other areas in terms of physio-chemical analysis. It can be concluded that water quality parameters can have a variation under different land covers. Streams variations of physical water quality could be associated to land use changes. It could be observed that water samples from agricultural areas showed an increase of temperature, color, turbidity, conductivity than the other areas. In conclusion, the overall result of my study can help in safeguarding streams and protection of the health of watershed residents. In addition, research findings can inform government and non-governmental organizations with responsibilities for the management of water resources on watershed landscapes. However, further investigation is required to determine the relationship between water quality, quantity and different land use patterns in another headwater sources as well as along the four streams which flows into the Inlay Lake.

Assessment on the Water Quality under Different Land Covers in Inlay Watershed Areas

1. Introduction

Land use patterns have important effects on aquatic ecosystems including water quality within a watershed (Lee et al., 2009; Tran et al., 2010; Rothwell et al., 2010). Inappropriate land use and practices in a river basin, such as population increase, urbanization, and industrial and agricultural activities can cause numerous problems related to water quality (Ngoye and Machiwa, 2004) as these anthropogenic activities are directly reflected in the land use characteristics of river basins (Kang et al., 2010). The relationships between land use patterns and water quality at a watershed scale explained variations of river water quality in water resource conservation and watershed ecosystem management (Woli et al., 2004; Li et al., 2009).

Surface water is susceptible to pollution from natural processes, such as precipitation inputs and erosion, and from anthropogenic disturbances through agricultural, industrial, and urbanization activities that increase the consumption of water resources (Shrestha and Kazama 2007; Singh et al. 2004). Anthropogenic disturbance has received much attention due to landscape modifications and ecosystem alterations (Maloney and Weller 2011). The change of land use types, including deforestation (Walling and Fang 2003), river channelization and realignment (Tong et al. 2009), and the fragmentation of continuous habitats (Miserendino et al. 2011) has resulted in soil erosion, a decline in aquatic biodiversity or scarcity, and water quality degradation. Previous studies have demonstrated that the relationship between land use change and the alteration of water physicochemical characteristics is influenced by numerous factors and varies from local to basin or eco-regional scales (Brion et al. 2011; Mehaffey et al. 2005; Tong and Chen 2002; Wear et al. 1998; Williams et al. 2005).

Forests and water are highly important resources which provide many functions and services to human societies and the environment. However, the occurrence of disturbance on forests modifies and alters the discharge, chemical quality and physical properties of water (Assefa Dessie et al., 2013). Forest in upstream watersheds is the best land cover to maximize water quality and support constant yield for agricultural and domestic uses, preventing floods in downstream areas, regulate seasonal flows and ensure high water quality (Tomar, 1999). Forested watersheds generally offer high quality of water than watersheds under alternative land uses because agriculture, industry and settlement are likely to increase the amounts of pollutants entering headwaters in addition to regulating erosion and reducing sediment load (Stolton, S. and Dudley, N. (ed), 2007).

Owing to environmental and socio-economic drivers, water quality and quantity have also become issues of global concern. Guo, H.et.al., (2008). Therefore, immediate attention should be paid on the problem of water pollution and sedimentation associated with land cover changes.

2. Problem Statement

In the last decade, the lake has been facing with combined threats due to natural and manmade pressure that become causes of decrease water holding capacity, changes in water quality. The direct causes of deforestation in Inlay lake watershed areas are depending on factors such as the expansion of shifting cultivation, livestock production and fuel wood harvesting, transformation of forest areas into permanent croplands and so on. Timber harvesting, grazing and fires can also severely degrade the forests. But the indirect cause of deforestation is population pressure in the lake as well as surrounding area of the lake (Mu Mu Than, 2007). Due to increased population pressure, these ranges have been stripped bare of trees for fuel wood and cultivation by the local people for their livelihood. Therefore, large scale deforestation and shifting cultivation practices are threatening severely the environmental stability of the entire watershed area of Inlay Lake. Deforestation and more intense agriculture on its western and northern watershed areas contribute to soil erosion reduce water quality and bring in increasing amount of silt and nutrients into the shallow lake. As a consequence, sedimentation and siltation had been seriously affecting the surface area of the lake and which has shrunk within the living memory. The water pollution is also caused by pesticides and fertilizers from the floating tomato gardens scattered across the surface of the lake. Eventually pollution of the lake water has been detected by random evaluation of the lake water quality. Thus technical measures are urgently needed to access the environmental degradation with respect to deforestation, disposal of solid garbage, sedimentation and water pollution of Inlay Lake.

3. Objectives

The main objective is to access hydrological characteristics (water quality) of a watershed under different land covers for the contribution towards watershed ecosystem management. The specific objective is to access physical status of stream water quality under different land covers for five months in the rainy season.

4. Methodology

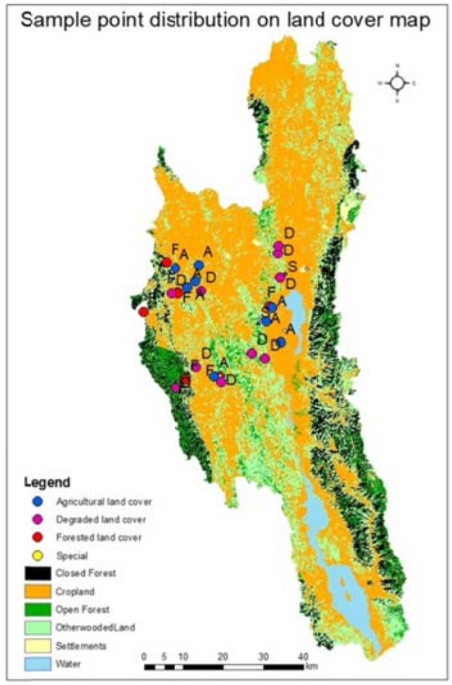
4.1 Study area

The geographical position of the Inlay Lake is between latitude 19° 46' North and longitude from 96° 47' to 97° 6' east. The surface of Inlay Lake is at an altitude of 884.03 m a.s.l. (the average over 15 years). The north-south axis is about 18 km and east-west axis is about 5 km. Kalaw watershed area is 292.41 sq-miles and sloping ranges from (<8% to >58%) and Nant Latt watershed area is 455.5 sq-miles and Ye Pae watershed area is 101.22sq-miles (Department of Irrigation, 2011). Core area of Inlay Lake is 72,100 Acres including Saka Lake & Moe Bywe Reservoir. Buffer area is 281,800 acres including Nyaung shwe Township and surrounding paddy fields, natural forests, taungya and other villages and remote area is 1,032,850 acres including head water area of Inlay Lake outside of the Core Area and Buffer Area.

4.2 Criteria for selecting study area

There are twenty nine streams flowing into the Inle lake, the four main streams, Kalaw, Nant Latt, Upper Balu and Ye Pae are perennial but the rest of the others are seasonal. Study areas were chosen based on the land cover map. Among five major types of land cover, three types of land cover were chosen based on the land cove map (FRA, 2015). There are about 139 head water sources in Inlay watershed area. Water samples (19) are collected from the head water sources to represent the forest land cover and its lower section for agricultural land.

Figure1. Study Area Map



4.3 Data collection method

4.3.1 Water Quality Analysis

Water samples are collected under three types of land cover; forested, degraded and agricultural land covers which were classified based on the land cover map (FRA-2015). In May, 11 water samples (4 forested sites, 1 degraded site, 6 agricultural sites) were collected from the head water sources and its lower sections. In June, 10 water samples (4 forested sites, 6 agricultural sites) were taken. In July, August and September, 19 water samples (5 forested sites, 7 degraded sites and 7 agricultural sites) were collected.

Time series and point data were collected for the investigation of water quality parameters.

Some water chemical properties (dissolved oxygen, conductivity, pH and temperature) were measured in the field. This can be done with a pH-meter, conductivity meter and an oxygen probe with a yellow spring. Alkalinity, color and turbidity are also water quality variables analyzed in the laboratory. All samples were collected using plastic bottles commonly used to seal purified drinking water. The samples were taken just below the surface of flowing water, by directing the opening of the sampler upslope. Samples were analyzed at Forest Research Institute (FRI) laboratory in Yezin. Water samples were collected at monthly intervals from May 2017 to September 2017 from (19) sampling stations. Chemical and physical water quality was surveyed at the headwater source near the Inle Lake and Kalaw, Aungban and Tigit as well.

4.3.2 Statistical analysis

Variations in land use/land cover were analyzed using descriptive statistics. Differences in physicochemical parameters for the different sites were tested by a one-way analysis of variance (ANOVA) with the SPSS version (20) package. Variations in water quality due to seasons as well as under different land covers were analyzed using one-way ANOVA and post-hoc test.

5. Result and Discussion

5.1 Water Physio-chemical Quality Analysis

5.1.1 Temperature

Temperature is significantly different in spatially but not in monthly. Temperature under forest land cover is significantly different with agricultural land but not different with degraded land. Specifically, temperature from and forested land is lower than agricultural land however, it is not different monthly. The temperature of headwater streams is variable, but as the downstream water volume increases and becomes more constant, the range of temperature variation decreases. Figure 2 shows that the comparison of temperature between different lands covers for the five months of rainy seasons.

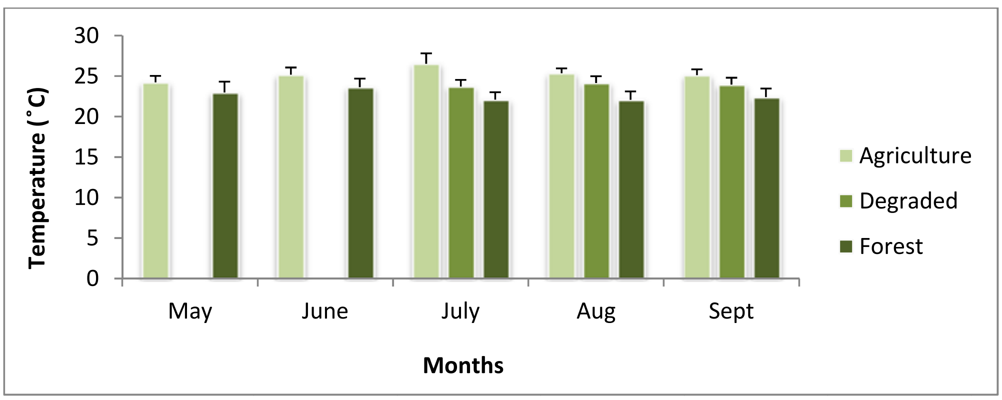


Figure 2: Difference of temperature under different land cover for rainy seasons (Source: Field survey 2017)

5.1.2. pH

The pH value of water samples was significantly difference in monthly but not spatially. But high pH value was found in the samples from agricultural land which tends to facilitate the solubilization of ammonia, heavy metals and salts. The precipitation of carbonate salts is encouraged when pH levels are high. Figure 3 shows that the comparison of pH between three lands covers for five months.

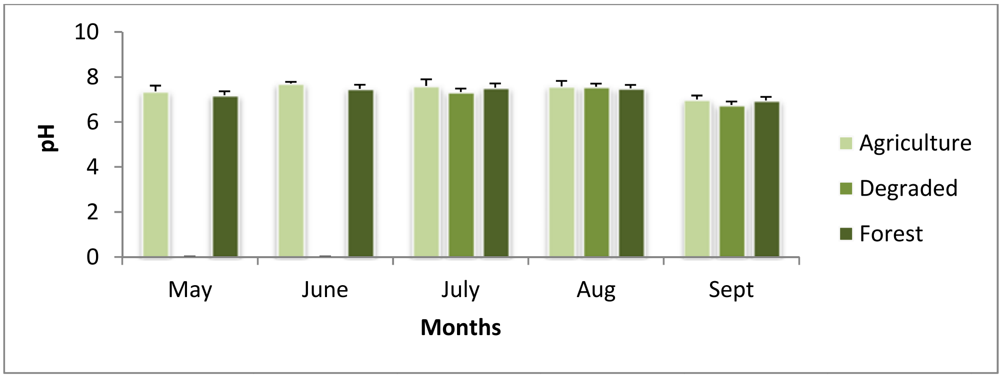


Figure 3: Difference of pH under different lands covers for rainy seasons (Source: Field survey 2017)

5.1.3. Conductivity

The conductivity of water samples is significantly different between three land covers as well as those values were varied monthly. The highest value of conductivity was seen in degraded and forested areas. The higher the dissolved material in water or soil sample, the higher the conductivity will be in that material. The higher the dissolved salt or ion concentration, the more conductive the sample and hence the higher the conductivity reading. Conductivity measurements can vary greatly and are affected by several environmental factors including, climate, local biota (plants and animals), bedrock and surficial geology, as well as human impacts on the land. Temperate streams and lakes, especially those with a significant groundwater contribution, generally have higher electrical conductivities. Figure 4 shows that the comparison of conductivity between three lands covers for five months.

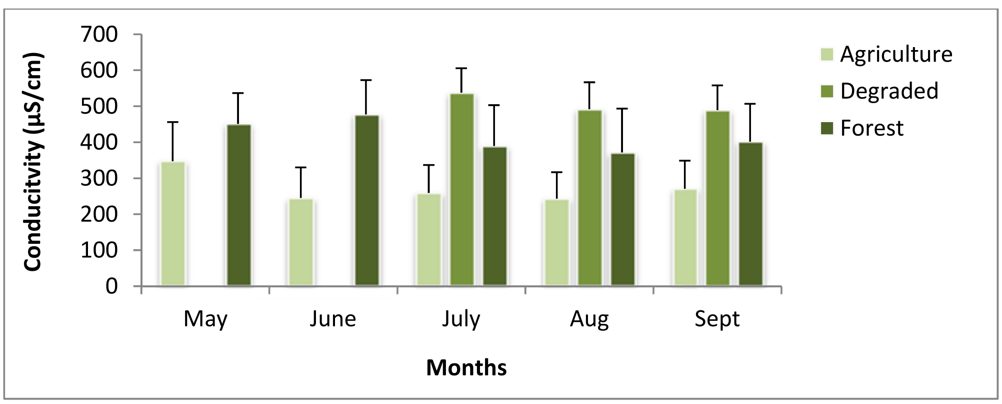


Figure 4: Difference of conductivity under different lands covers for rainy seasons (Source: Field survey 2017)

5.1.4. Dissolved Oxygen

According to the result from dissolved oxygen, significant change between three different land covers was observed but it varied seasonally. Dissolved oxygen presented highest values in the water samples from forested land, then decreasing in the samples from degraded and agriculture land according to the decrease of native forest percentage in the watershed. Dissolved oxygen is essential to the respiratory metabolism of most aquatic organisms. It affects the solubility and availability of nutrients, and therefore the productivity of aquatic ecosystems. Low levels of dissolved oxygen facilitate the release of nutrients from the sediments. Figure 5 shows that the comparison of dissolved oxygen between three lands covers for five months.

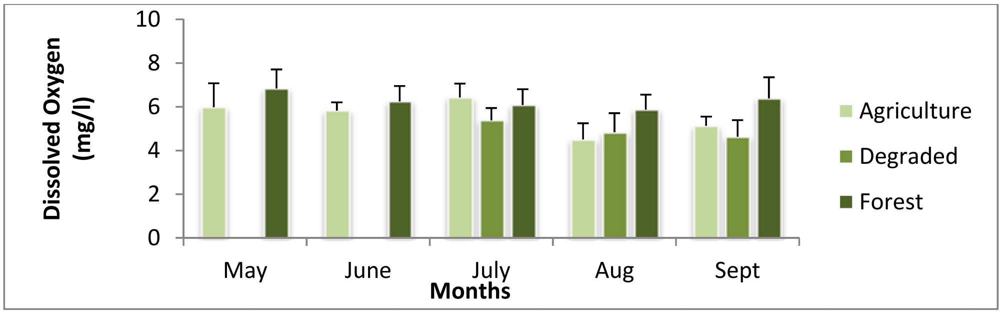


Figure 5: Difference of dissolved oxygen under different lands covers for rainy seasons (Source: Field survey 2017)

5.1.5. Alkalinity

In addition, alkalinity was significantly varied under three different land covers. Agricultural land has low alkalinity than forested and degraded land. Alkalinity values are significantly different spatially, in addition, degraded and forest lands have high those values than agricultural sites. This may be due to some dissolved mineral elements in the water like calcium because most of the watershed areas (degraded and forest lands) are covered with calcareous mountains. If a body of water has a high alkalinity, it can limit pH changes due to acid rain, pollution or other factors. Alkalinity is a measure of the buffering capacity of water, or the capacity of bases to neutralize acids. Measuring alkalinity is important in determining a stream's ability to neutralize acidic pollution from rainfall or wastewater. The alkalinity of water varies due to the presence of dissolved salts and carbonates, as well as the mineral composition of the surrounding soil. Figure 6 shows that the comparison of alkalinity between three lands covers for five months.

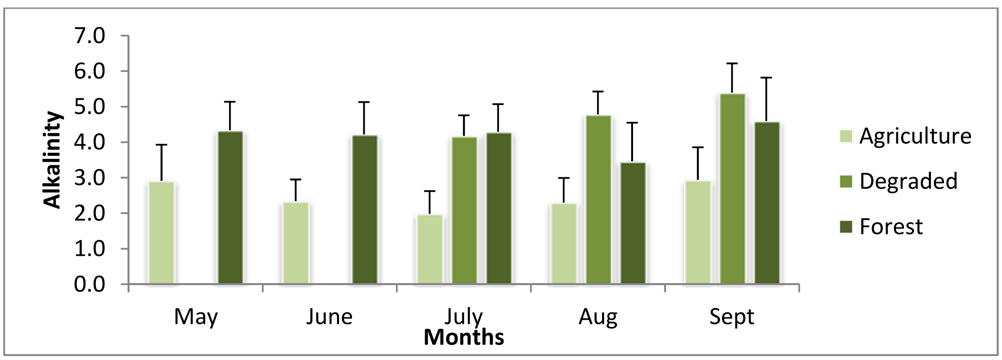


Figure 6: Difference of alkalinity under different lands covers for rainy seasons (Source: Field survey 2017)

5.1.6. Turbidity

Water sample from agricultural site is higher in turbidity than forest and deforested area. Those values in July were significantly different with other months. Water flow, point source pollution, land use and are the factors that can affect turbidity. High levels of turbidity increase the total available surface area of solids in suspension upon which bacteria can grow. Highest turbidity values were observed in agricultural water samples; therefore, it impairs photosynthesis of submerged vegetation and algae. In turn, the reduced plant growth may suppress fish productivity. Turbidity interferes with the disinfection of drinking water and is aesthetically unpleasant. Figure 7 shows that the comparison of alkalinity between three lands covers for five months.

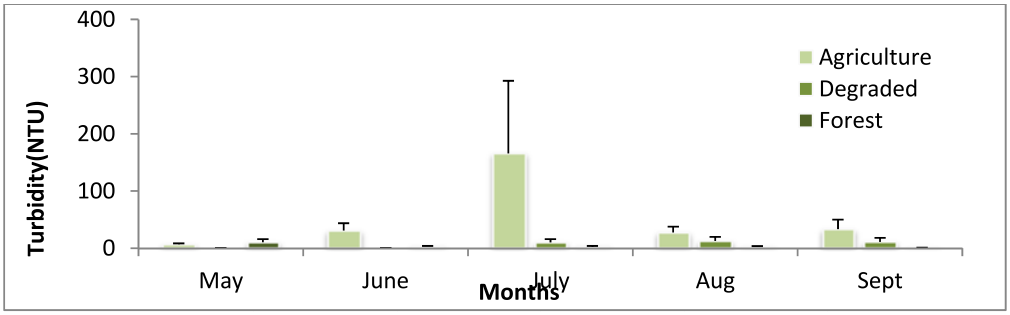


Figure 7: Difference of alkalinity under different lands covers for rainy seasons (Source: Field survey 2017)

5.1.7. Color

In addition, water sample from agricultural site is higher in color than forest and deforested area. Those values in July were significantly different with other months. Color values in agricultural samples also show higher values than the other two samples. Figure 8 shows that the comparison of color between three lands covers for five months.

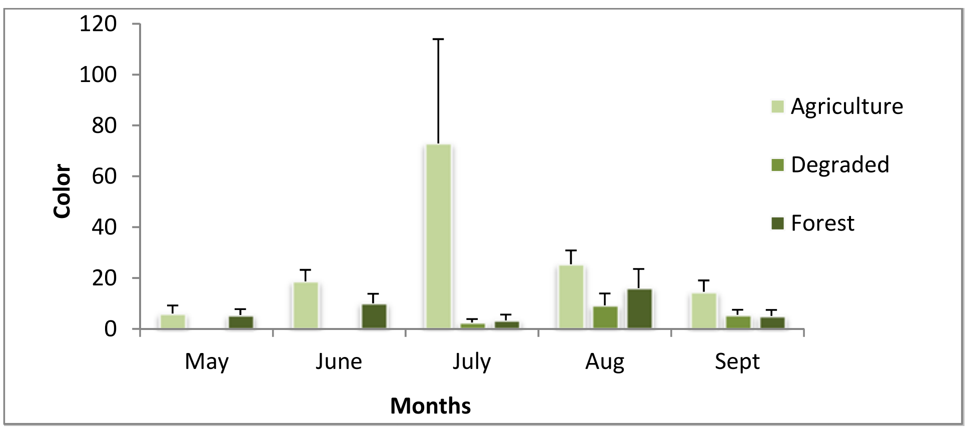


Figure 8: Difference of color under different lands covers for rainy seasons (Source: Field survey 2017)

Table1. Mean value ± standard error for water quality characteristics analysis for three different land covers (agricultural land, degraded land and forested land)

Parameters	**Agricultural Land** (Mean ± SE)	**Degraded Land** (Mean ± SE)	**Forested Land** (Mean ± SE)
Temperature	25.07 ± 0.29*	23.81 ± 0.50*	22.66 ± 0.42*
Conductivity	278.03 ± 33.01*	534.22 ± 36.93*	407.11 ± 41.48*
pH	6.73 ± 0.23	5.57 ± 0.4	6.37 ± 0.28

Oxygen	6.45 ± 0.28	6.39 ± 0.41*	6.9 ± 0.27*
Alkalinity	2.49 ± 0.31*	4.91 ± 0.45*	4.07 ± 0.39*
Turbidity	134.69 ± 61.1*	6.76 ± 2.22*	17.8 ± 14.36*
Color	67.63 ± 28.04*	3.61 ± 0.67*	8.37 ± 1.88*

* The mean difference is significant at the 0.05 level.

Table2. Mean value ± standard error for water quality characteristics analysis for three different land covers sampled in five months.

Parameters	**Months**				
	May	June	July	August	Sept
Temperature	23.69 ± 0.65	24.39 ± 0.63	23.72 ±0.55	23.97 ± 0.54	23.9 ± 0.54
Conductivity	380.5 ± 63.51	377.41 ± 54.46	417.08 ± 55.2	381.47 ± 53.74	396.93 ± 215.19
pH	7.3 ± 1.4*	7.61 ± 0.08*	5.58 ± 0.31*	5.01 ± 0.46*	6.88 ± 0.41*
Oxygen	6.42 ± 0.62	6.03 ± 0.32	7.43 ± 0.12*	7.55 ± 0.97*	5.25 ± 0.44*
Alkalinity	3.46 ± 0.61	3.18 ± 0.53	3.4 ± 0.49	3.65 ± 0.49	4.41 ± 0.58
Turbidity	233.34 ± 160.85	52.77 ± 35.12	62.4 ± 46.33	14.64 ± 4.82	15.42 ± 6.41
Color	121.36 ± 76.97*	14.48 ±2.9*	24.99 ± 16.04*	16.13 ± 3.48*	29.95 ± 11.3*

* The mean difference is significant at the 0.05 level.

There is a significant difference between water samples under three different land covers in alkalinity, conductivity, oxygen, turbidity and temperature at ($p< 0.05$) (Table 1). According to the analysis of variance result, there is a significantly difference in water quality parameters such as pH, oxygen, color in case of monthly at ($p< 0.05$) (Table 2).

In general, stream water quality was higher in agricultural land covers. Several studies reported the impact of land use effect on streams, both in temperate and tropical watersheds (Kamisako et al. 2008, Rai et al. 2010, Andrade et al. 2011, Silva et al. 2011). Generally, the results from this study show no significant difference between waters from forest and deforested areas but significant difference between agricultural and other areas in terms of physio-chemical analysis.

7. Conclusion

The results of this study show the physical status of stream water quality under different land covers during the rainy seasons in Inlay watershed areas. On the other hand, were not observed large differences between degraded and forested streams. Therefore, stream water quality in agricultural land covers was largely affected by many agricultural practices and anthropogenic activities. Moreover, seasonal variation was observed in some water quality parameters indicating that there was more significant impact in the end of rainy season than that of the first rainy seasons.

8. Acknowledgements

This study was supported by the Norwegian Institute of Water Research (NIVA) for both financial and technical supports as well as laboratory analysis. In addition, I am highly grateful to supervisor and co-supervisor for their effective supervision to my study.

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