Analysis of Total Suspended Solid (TSS), nitrite, nitrate and runoff changes during rainfall events at River Kurambik, Lake Maninjau

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Abstract. Lake Maninjau is a caldera lake with a volcano-tectonic type. The existing land management of Lake Maninjau catchment area influenced water quality, included River Kurambik as one of the rivers that flow into Lake Maninjau. It influenced degradation of water quality, nutrient enrichment and exceeded the carrying capacity. The source of pollutants, especially non-point sources pollution can be a point source in large numbers. For example, runoff from agricultural areas containing pesticides and fertilizers, runoff from residential areas (domestic). In order to gain insight into the effect of watershed conditions on water quality in Lake Maninjau, we statistically analyzed Total Suspended Solid (TSS), Nitrite, Nitrate, discharge, water temperature (Tw) and, air temperature (Ta) at River Kurambik, Lake Maninjau. Besides water level and water temperature (HOBO sensor), also Teledyne ISCO sampler equipment was used to take sample water for analysis. Some results showed the relation among parameters such as TSS, Nitrite, Nitrate, discharge, and water temperature as long as our observation in periods September – November 2018. Based on data, it could be explained that the seasonal variability of atmospheric conditions influenced fluctuations in air and water temperature nearly proportionally ($R^2 = 0.883$). The change of discharge influenced Total Suspended Solid (TSS) significantly ($R^2 = 0.917$). It indicated the land use change contributed to the water quality during rainfall events through runoff sediment and materials into the lake. On the other hand, Nitrite, Nitrate parameters seemed to have various changes during rainfall events. The land use management and economic values of these lakes and ecosystem should be elucidated. In order to maintain the sustainability of the lake, land cover management at the catchment area is also necessary for the next study.

1. Introduction

River Kurambik is one of the rivers that flow into Lake Maninjau that also be contributed to the water quality in the lake. The land use of River Kerambik watershed influenced the water quality supplied into the lake. Lake Maninjau is a caldera lake with a volcano-tectonic type. Its formation process is divided into 3 phases[1] namely, the volcanic caldera collapsed due to a large eruption 60,000 years ago, then subaerial sediment and avalanches. The last step is debris fans accumulated inside the floor and edge of the caldera. This lake is located in Agam District - West Sumatra and has an important role in daily life and the beauty of the lake (Fig.1). The average depth of lake Maninjau is 105 m which covering 13,260 ha of an area with a height of 461.5 m above sea level and a maximum depth of 165 m [2]. The lake water comes from rainfall, small rivers, and the surrounding groundwater, and one outflow in Batang Antokan River.
Currently, Lake Maninjau has economic functions as a power plant that produces the annual rate of 205 GWH of energy, sources of irrigation water, fishing fish farming in floating cages and catching, and tourism destination [3 & 4]. In addition, from ecological functions, Lake Maninjau could control the water balances of soil, microclimate, and habitat for organisms.

Besides hydropower, the utilization of Lake Maninjau also for fish farming activities in the floating net. Cultivation of fish in floating net began in 1990. Fish farming activities in floating net have increased the high economic growth for local communities. However, since 1997, this activity began to decrease because of frequent death of fish caused the loss of business. Since a public complaint, a decrease in water quality of the lake is causing economic loss to the community or local government from both fish farming activities in the cages and tourism. Besides fish farming in floating cages, Lake Maninjau is also used for tourist activities, especially by foreign tourists [5]. The development of tourism activities also led to the growth of the hotel or inn and restaurant around the lake. But the lake’s water quality such as murky water and odor caused a decline in tourist numbers and the impact on the economy of the community and local government.

In early January 2009, more than thirteen thousand (13,000) tons of disaster death of fishes occurred at Lake Maninjau. From measuring the water quality of lake from observation by Limnology station - Research Centre for Limnology LIPI, on January 2009, reported a drop of dissolved oxygen (DO) 1.05 mg/l in water surface (normal conditions approximately 7 mg/l) with temperatures 28°C and pH 7.17. At three meters of water depth, dissolved oxygen (DO) content had reached 0.46 mg/l and temperature 27.2°C. The water column is normally used for the floating cage. The low oxygen content was causing mass death of fishes. This disaster is related to what is called by local people "tubo sulfur." Generally, sulfur tubo phenomenon has occurred at the beginning of the year. Besides, there is a possibility of circulation influence on the vertical profiles of dissolved oxygen in some of the lakes, where related to the seasonal meteorological patterns [6].

Lake Maninjau has strategic values such as hydro-electric power plant, tourism, agriculture, capture fisheries, and floating net cages farming. It influenced the degradation of water quality, nutrient enrichment, and exceeded the carrying capacity. The source of pollutants, especially non-point sources pollution, can be a point source in large numbers. For example, runoff from agricultural areas containing pesticides and fertilizers, runoff from residential areas (domestic).

![Location of Lake Maninjau and their several main and tributaries rivers.](image_url)
The lack of consideration of discharge aspects during rainfall events from the river that could play important roles in lake’s water quality condition has suggested the necessity of its investigation. The objective of this study is to analyze Total Suspended Solid (TSS), Nitrite, Nitrate, discharge, water temperature (Tw), and air temperature (Ta) response to rainfall events at small River Kurambik, Lake Maninjau.

2. Methods
A survey at Lake Maninjau was conducted from September until November 2018. Not only survey at the field but also to collect the secondary data such as climatological data for supporting the analysis.

River Kurambik is one of the rivers that flow into Lake Maninjau. Administratively, it is located in Tanjungraya sub-district, Agam Regency, West Sumatra Province, Indonesia. Geographically, it lies on 0° 14’ 52.50” S - 0° 24’ 12.17” S and 100° 08’ 53.84” E - 100° 14’ 02.39” E. The Kurambik sub-watershed area is 1,000 Ha, or 10% of the total Maninjau watershed (96,000 Ha). Figure 2 shows the location of the measurement site. The selected location covered forest, plantation paddy field, and bush (Landsat 8 OLI, 2018).

We had selected Total Suspended Solid (TSS), Nitrite, Nitrate, discharge, water temperature (Tw), and air temperature (Ta) parameters in the small River Kurambik watershed area (279.3 ha) during September - November 2018. To gain insight into the effect of small watershed conditions on water quality in Lake Maninjau, we statistically analyzed all those parameters at River Kurambik. Water sampling measurements were obtained for every 5 cm changes (rise and fall) of water level by using Teledyne ISCO sampler equipment (Fig. 3 & 4)

Figure 2. River Kurambik location, part of inflow river at Lake Maninjau and its land cover in 2018.
Figure 3. Teledyne ISCO sampler equipment (left) and small River Kurambik (right).

Figure 4. Setting the equipment for supporting analysis (left-right: rainfall, water level and water sampler).

3. Results and Discussion
Based on measurements of rainfall and discharge at River Kurambik, it obtained the relation between rainfall and discharge as described in Fig. 5. The Frequency of rainfall events is more often found after August as a wet season in Indonesia.

Figure 5. Rainfall vs. Discharge at River Kurambik.
Water temperature and its change are critical factors for aquatic physical, chemical, and biological processes [7 & 8], and it remains the subject of world-wide environmental research [9]. Next, water temperature and water quality are important variables affecting the health, biodiversity, and productivity of freshwater ecosystems [10, 11 & 12]. At small watersheds, runoff water will move quickly, and the flow time of groundwater is relatively short if water infiltrates the groundwater layer; then, the water temperature could not be far from rainwater temperature, which follows air temperature [13 & 14]. Probably, this is the reason for the considerably high variability of water temperature at small watersheds.

![Figure 6](image1.png)

**Figure 6.** Air temperature (Ta) vs. water temperature (Tw) at River Kurambik.

Figure 6 shows that the high value of $R^2$ can be explained by noting that the seasonal variability of atmospheric conditions influenced air and water temperature fluctuations nearly proportionally.

![Figure 7](image2.png)

**Figure 7.** Discharge (Q) vs. water temperature (Tw) at River Kurambik.

On the other hand, based on Fig. 7, there was not a significant correlation ($r = 0.555$) between discharge and water temperature. It suggested that various water temperatures are primarily controlled by exchanging of heat across the water surface (atmospheric heat exchange).
Figure 8. Correlation between Tw vs. Nitrate (a); Tw vs. Nitrite (b) and Tw vs. TSS (c).

Figure 8 shows that the water temperature can change the concentration of substances in water. It showed from among correlations, between Tw and Nitrate, the concentration of Nitrate decreased with increasing water temperature (Tw), indicating that water temperature influenced such concentration of Nitrate. This phenomenon was not obtained for Nitrite and TSS.

Figure 9. Correlation between Q vs. Nitrate (a); Q vs. Nitrite (b) and Q vs. TSS (c).
Meanwhile, Fig. 9 showed discharge could change the concentration of substances in water. It showed from among correlations between $Q$ and TSS, the concentration of TSS increased with increasing discharge ($Q$), indicating that discharge influenced such concentration of TSS. This phenomenon was not obtained for Nitrate and Nitrite. It could be assumed that TSS was easier to move by flushing of water flow (discharge) during rainfall events. It could be elucidated that during rainfall events, the concentration of TSS will be increased with the increasing discharge ($Q$) and implied the condition of water quality on the river.

4. Conclusion
Seasonal variability of atmospheric conditions influenced air and water temperature fluctuations near proportionally. Meanwhile, at small watershed, rainfall events and surface runoff influenced the change of Total Suspended Solid (TSS) with the value of $R^2 = 0.917$. It could be explained that the existing land management influenced water quality. In order to maintain the sustainability of the lake, land cover management at the catchment area is also necessary for the next study.

Declaration
Luki Subehi is main contributor for this Research publication

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