Alternative Water Resources in UPNM

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ABSTRACT--- Water crisis is become a global issue in recent decade. Alternative water resources are an important method to mitigate the issue of water shortage. The aim of this research is to identify and compare the alternative water resources in UPNM campus. The study of water catchments in UPNM campus was conducted to examine the amount of water resources available that can be developed for water supply. The water quality of the stated alternative resources was tested and analysed to propose new alternative water resources for UPNM campus. Rainwater from the pervious area in UPNM, multipurpose green field and natural water from Lestari area surface water collection area were selected for raw water quality standard. To justify the quality of water, physical, chemical and biological assessment were performed. Water quality from each parameter is determined based on American Public Health Association Method (APHA).Peak flowrate of water discharged from both areas were determined using Rational method. Based on the analysis from the study, Lestari area without rain shown a better result whereby WQI for this location is 88.59 compared to UPNM multipurpose green field area which is only 71.68 and a result of 61.17 of WQI for Lestari area with rainwater.

Index Terms— Alternative water resources, rational method, water quality, water supply.

I. INTRODUCTION

Water will be the most significant resource especially in 21st century. The increment of human population causes the water demand has increased. The fast growth of agriculture, population, industry sectors, have contributed the pressure of water supply, and consequences to water shortage over the world. Besides natural water resources like stream, lake, and river basin, alternative water sources are also starting eager by human to overcome the scarcity of water in the future. Therefore, people tend to be starting developed and researching on others water supply such as rainwater harvesting, reused greywater, reclaimed water and desalination. By exploring the new water resources and invent new technologies to generate extra or replace current water supply to reach the water demand for cur-rent situation and future [1].

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Reused rainwater is one of the most popular method to solve the problem. Some expert has found that the characteristic of harvested-rainwater system attracted for performing in urban and rural area, mostly in drought or arid season and lead to the water shortage [2]. Another potential water resource is grey water. Grey water is defined as the waste water that used in house hold such as kitchen water, bathing water, washing machine, except the toilet water and water flush which is labelled as "blackwater". The volume of water consumed for drinking and cooking is lesser than the water used in washing machine, showering, gardening and toilet flushing, or even kitchen used [1]. The benefits of reuse greywater are to decrease the usage of freshwater, may utilised the water for drip irrigation or garden watering, replace the water flushing to greywater may save the cost.

In Malaysia, there are around 3% or less than that of water sources that utilise is from groundwater. The research of groundwater extraction is done by [3] to investigate another water resource to mitigate the water crisis in UPNM. 3 different locations of the tube well were study with the average flowrate of 1.59 m^3/hr were determined in the area of UPNM campus.

This study is to compare two various locations, different characteristic of water resources in UPNM campus. Two selected water resources include pervious surface runoff harvesting and surface water (ground surface water) is studied.

II. METHODOLOGY

Submit your manuscript electronically for review. The methodology of determining the most suitable water resource for mitigating the water shortage in UPNM is discussed. Firstly, the methodology of this study is starting with finding journals, articles from the channel of internet, libraries and books. Secondly, the data and sampling collection is practiced for the laboratory test. Two ideal location for sampling location is decided and shown in Fig. 1 which are Lestari area and multipurpose green field in UPNM. Water is collected in condition after rainfall event and without rain. From here, the water quality from each of the parameter is performed accordance with the American Public Health Association Method (APHA) and analysed by following Standard Water Quality of Malaysia and Water Quality Index.In the addition, water quantity of alternative water resources in UPNM is analysed by using Rational method. Finally, the analysis of water quality and water quantity had offered the researcher to determine the definite value of water resources.

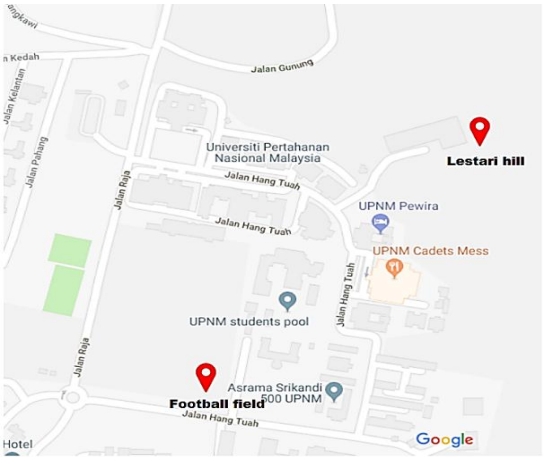

Fig. 1: Location of sampling area

A. American Public Health Association Method (APHA)

Standard Methods for the Examination of Water and Wastewater is one of the most popular water quality reference for practice analysis. The process of experimental is included sample collection and sample laboratory test. There are nine laboratory tests will be conducted with each of the parameter based on the water quality standard [4]. For sampling collection, numbers of 1L bottles is prepared, washed and rinsed with distilled water to ensure there is no other tiny particle or impurities inside the bottle. This step is to prevent from get the error result. As there is involved with two locations sample, so for not getting confusion, marking is needed on the bottle. Most effective result is obtained with fresh samples. If the samples are tested within 24 hours of collection, samples must be store in temperature 4 ºC. Table 1 shows the code of the Standard Method and the parameter assessment.

Table 1: Standard method code and parameter for testing

Assessment	Code (Standard Method)	Parameter
Physical	2550 B	Temperature
	2540 D	Total suspended solids
	2130 B	Turbidity
Chemical	2310, 2320	pH (Alkalinity, acidity)
	5220 C	Chemical oxygen demand
	5210	Dissolved oxygen
	5210 B	Biological oxygen demand
	4500-NH3	Ammonia Nitrogen
Biological	9215 C	Heterotrophic Plate Count

There is different condition for biological assessment. The glass Duran bottles are prepared. Bottles must be autoclaved in temperature 121 °C to make sure it is sterile and not contaminated. For all the bottles, cap bottles must be loosened before autoclaving to prevent crack once it will expand during hot temperature. As microbiological test is very sensitive, those apparatus, chemical indicators, equipment are necessary free from bacteria and contamination. Therefore, once conducting HPC test must be in a laminar flow cabinet.

Fig. 2: Laminar flow cabinet and apparatus of HPC test

B. Rational Method

Rational method is one of the scientific technique that frequently used in Malaysia with the purpose of calculating the runoff peak estimation or water surface runoff. This method is normally applied when the peak flow of runoff occurs at the certain point that flowing from entire tributary. This method is suggested for the catchment area that is lower than 80 ha [5]. Equation (1) of rational method is to define the flowrate of peak runoff, Q.

$$Q = \frac{C.i.A}{360} \quad (1)$$

Functionally, the formula relates with peak flows (Q) in m^3/s, runoff coefficient (C), average rainfall intensity (i) in mm/hr, and area of the drainage (A) in hectare. The coefficient value C act as the dependent variable and varies with the area of catchment or drainage, rainfall intensity and so on. Coefficient of runoff is the function for designing of land use in between the relationship of pervious and impervious region. For example, the impervious surface with the characteristic of low permeability, the recommended runoff coefficient will be higher compare to pervious area. In this research, the runoff coefficient is taken at open spaces; forest cover is recommended as the area of research (Lestari hill) is among the forest. The runoff coefficient for minor and major system is 0.30 and 0.40 respectively. The difference of minor and major systems are the design for less than 10 years ARI and vice in Malaysia, to minimise the error in estimating the value of rainfall intensity, empirical formula in (2) is expressed and developed with intensity-duration-frequency curves (IDF) [4]. This formula is basically used in large region area for example in a state or a town. Based on the investigation that now involve, the rainfall data are collected from the weather station UPNM. The rainfall intensity is interpreted and simplified from the data before the act as the parameter. Hence, in (2) is not able to use for this research purpose.

$$i = \frac{\lambda T^K}{(d+\theta)^\eta} \quad (2)$$

where average rainfall intensity (i) in mm/hr, average recurrence interval-ARI (T), storm duration (d) in hrs and λ, K, θ, η is original equation is generated for drainage area.

As the major purpose of this research is to define the flowrate from the discharging point from the surface water

catchment, hence, the parameter for this research is an area of catchment. The area of catchment is calculated by referring to the survey plan of UPNM. So, at the end of the research, the new parameter of formula will be expressed in (2). Functionally, the formula relates with peak flows (Q) in m^3/s, runoff coefficient (C), average rainfall intensity (i) in mm/hr, Rainfall data from weather station UPNM and area of the catchment (A) in hectare.

III. RESULTS AND DISCUSSION

A. Water Quality Test

The average of the results for physical and chemical assessment are stated in Table 2. From the result, it shows that Lestari area without rainwater provide the most positive result compare with multipurpose green field and Lestari area with the condition of raining. The status of water was classified in Table 3 which based on guideline National Water Quality Standard of Malaysia. The temperature of water sample in area Lestari was the highest 26.06 °C during the condition of without raining. Optimum temperature for both areas maintain appropriate dissolved oxygen in environment ecosystem. Same goes with the good result of TSS for condition without raining in Lestari area which is 15.15 mg/L, turbidity with result 15.15 NTU, neutral pH 6.25, 0.26 mg/L of nitrogen ammonia, 8.22 mg/L of COD, 5.52 mg/L of DO and 0.51 mg/L of BOD. Most of the parameter was classified in Class II. The guideline of water quality standard mentioned that the Class I is the best in range while Class V is the poorest in range.

Total suspended solid as one of the physical parameters. Based on Table 2, water sampling after rainfall event is classified as Class IV, cause by those solid particles like silt, clay and organic matter which settled down had been stirred up from the bottom of reservoir. Soil or solid matter flowed from the land and mixed with the sediment bring the concentration of total suspended solid increase. Photosynthesis is necessary to every plant, same with aquatic plant. This process converts light energy into chemical energy. Plant need carbon dioxide and sunlight to produce oxygen, aquatic life depends dissolved oxygen to survive and breathing. Higher turbidity will block the sun shine in to water even though bottom of water. Average of turbidity at location Lestari with rainwater is the highest compare to multipurpose green field and Lestari area without rain. As the surface water at Lestari area is in flowing state, hence the turbidity of water during slow motion is low and water is clean.

Another important chemical assessment is pH parameter. Based on Chapter 4 result, the average value of pH in Lestari area with rainwater and without rainwater is 5.53 and 6.25 respectively. Therefore, the specimen with rainwater is more acidic and classified as Class III which shown in Table 3 cause by acid rain. Surface water that without contacting with rainwater is in optimum range which nearly neutral this could be proven that acid rain is presence. For specimen from multipurpose green field, is the most acidic compare with others. This is because the soil under the ground is tend to acidic with the nutrient and mineral. Hence, the result of pH water is 5.14 which is Class III. The highest concentration of ammonia is 2.72 mg/L in Lestari area with rainwater. This bring the water classified in Class IV. Excess level of certain nutrient would cause variety of ecological and health consequence. Overabundance nitrogen and ammonia can boost up the growth of algae and aquatic plants, in order decrease the dissolved oxygen and block light, serious impact brings fish to kill.

Highest concentration of COD test in this study is 43.83 mg/L at Lestari area after rainfall. The results indicate that the water contacted with rainwater need extra oxygen to consume for decomposing the organic matter raw water and rainwater itself. High dissolved oxygen, more aquatic creature will stay in the area and vice versa. The data from DO test bring the status of Class III after raining event at the location Lestari area and multipurpose green field. Whereas, the highest concentration of DO is Lestari which is Class II in the condition of without disturb. During the research, researcher had observed that there were fish and frog stay at the man-made mini dam at Lestari. That location already acts as the habitat for aquatic creature. This can prove that the water at Lestari filled with high DO. The impact of low DO brought high concentration of BOD. The result of BOD is too low which is lower than 1. According to DOE Water Quality Index Classification, once lower than 1 mg/L, mean the water is very clean. Once the water is flowing, oxygen is easily entering to the void of water particle. Therefore, the data analysis had showed a positive BOD result to prove that water is enough DO for microorganism to separate the organic substances.

B.Microbiological Bacteria Test

The presence of total coliform and fecal coliform is not acceptable to be drinking for human [6]. This test is performed it is due to coliforms bacteria occur and live in soils, and from soil, the water is move through the soil, and this process is called infiltration, from here, the water source may occur with bacteria as it flow through soil and from here the water is associated with it. HPC test and gram staining were both conducted to observe that there is no coliform in both area of water. The characteristic of coliform is in rod-shaped gram-negative bacteria which can ferment lactose with producing gas and acid in the condition of incubating with the temperature at 35-37°C when growing in MacConkey agar. The microorganism that growth in MacConkey agar shows gram-negative but then with no rod-shaped.

Water quality index is functioned as the guide lines to justify the status and quality of water. The result of WQI is related and depends with sub-index value from each of the parameter. Accordance with Table 4, researcher able to judge that the status of water at Lestari area after the rainfall event is slightly polluted with result 61.17 it is in the range of 60-80. But then during the low flow which is without raining, the water is resulted as clean with value of 88.59 it is in the range of 81-100. For the one that classified as Class II is mean clean water. On the other hand, the WQI of football field is categorised as slightly polluted in 71.68.

Nevertheless, the water also need conventional treatment for water supply and suitable in body contact. Result that showing water is slightly polluted is Class III, the water must have an extensive treatment before supplying the water for usage.

C.Water Quantity Analysis

Water quantity also the important part of the research to identify the water point to be consumed by consumer. Rainfall intensity is calculated accordance with the rain gauge data from UPNM weather station. At this case, rainfall intensity is constant variable while catchment area is manipulated variable. In this research, 0.49 ha (part of area of multipurpose green field) as the catchment area of football field whereas 2.12 ha of catchment area at Lestari hill with the characteristic of forest cover.

Water flowrate, Q is represented the quantity of water. From Fig. 6, observing that water flowrate of Lestari hill is greater in double compare with flowrate of football field. Land use for football field is in grass cover. During rainfall event, rainstorm seep into the soil with the process of infiltration. Unlike pavement surface, football field is categorised as pervious land. Once the water particles fill in the pores of soil and replace air in the ground, land become wet. Extra water that over full-filled the void has no where to stay and starting discharge to drainage. The discharge water is the one collected as alternative water sources in UPNM.

Another research location is surface water at Lestari hill which the characteristic of water is like river stream. Hence, the flowrate of water will higher than football field it is because the water may from other sources, for example small river, groundwater and others.Lestari hill is surrounding with forest. A man-made mini dam is built for reserving the flowing water to reduce and control the flowrate. A data of water usage in UPNM is collected from Department of Maintenance, UPNM. The average volume of water had been consumed and used up in UPNM is 48000 m^3 per month. But then, if the present of alternative water resource is utilising it, UPNM at least can save up 5 % volume of usage. At the same time, the cost of water usage can directly become lesser.

Table 2: Result of water quality in each parameter

Location	Temp. (ºC)	TSS (mg/L)	Turbidity (NTU)	pH	Nitrogen (mg/L)	COD (mg/L)	DO (mg/L)	BOD (mg/L)
Lestari (Raining)	23.71	174.5	227.93	5.53	2.72	43.83	4.55	0.58
Lestari (w/o Raining)	26.06	15.15	13.68	6.25	0.26	8.22	5.52	0.51
M. green field (Raining)	23.77	34.69	40.3	5.14	0.64	33.55	4.25	0.33

Table 3: The classification of water quality

Location	Parameter								
	Temp.	TSS	Turbidity	pH	Ammonia Nitrogen	COD	DO	BOD	Coliform
Lestari (raining)	II	IV	-	III	IV	III	III	I	I
Lestari (w/o raining)	II	II	II	II	II	I	II	I	I
M. green field (Raining)	II	II	II	III	III	III	III	I	I

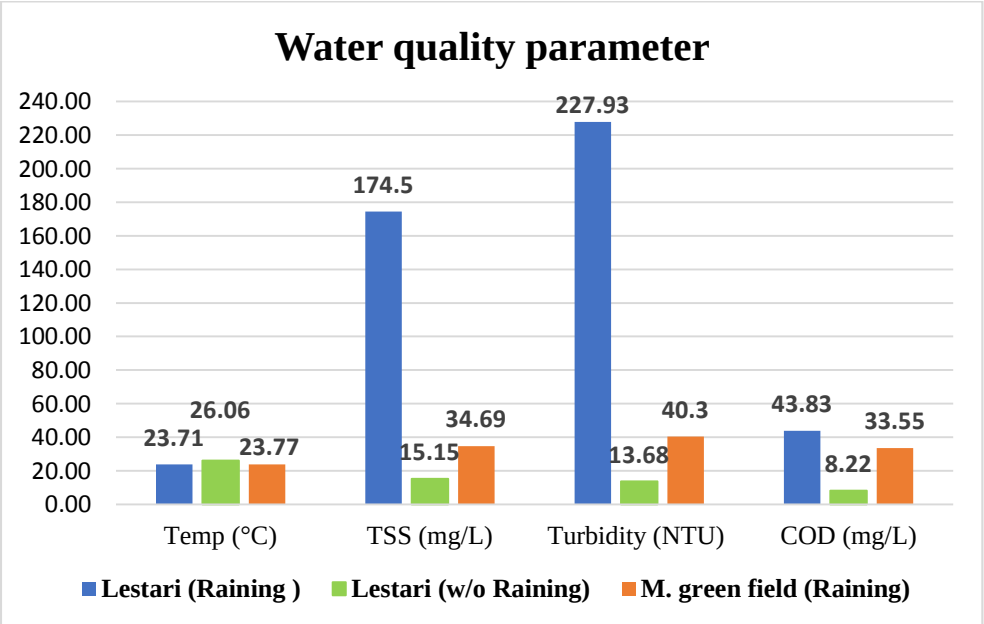

Fig. 3: Result water quality from each parameter

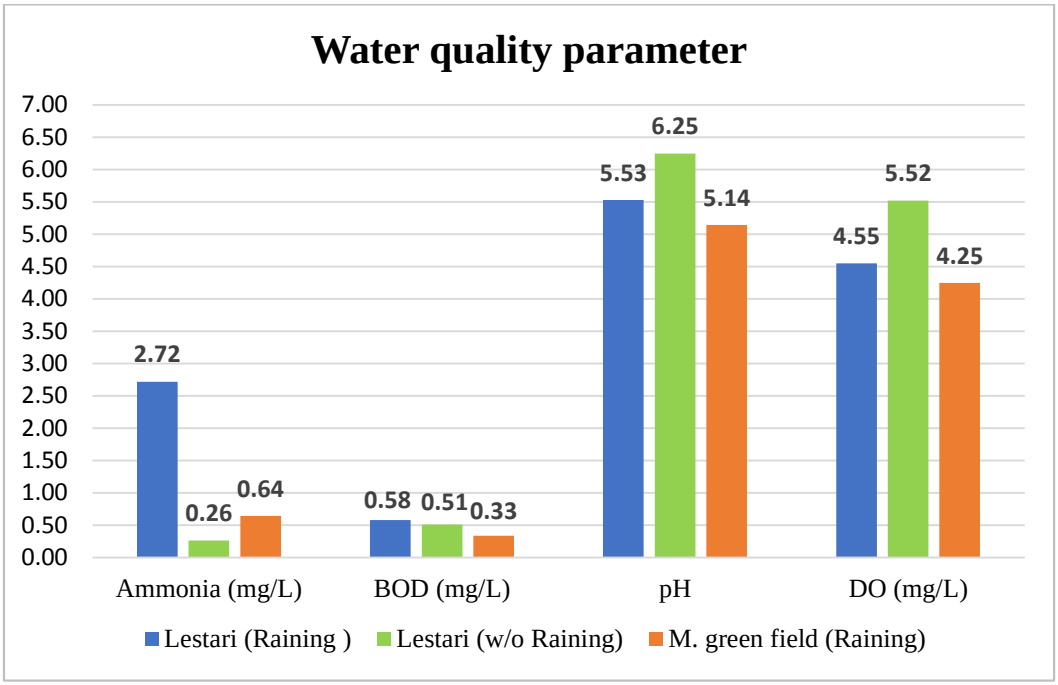

Fig. 4: Result water quality from each parameter

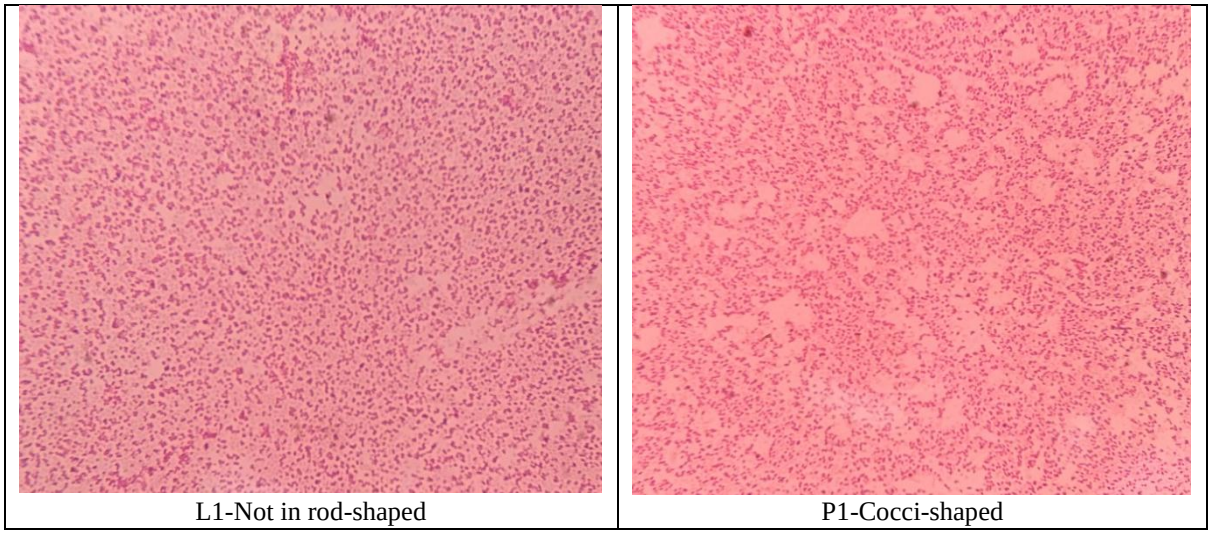

Fig. 5: Gram staining of both area with no presence of coliform (L1-Lestari, P1-Multipurpose green field)

Table 4: Water quality index in different location

Location	Sub Index								
	SIDO	SIBOD	SICOD	SIAN	SISS	SIpH	WQI	Class	Grade
Lestari (Raining)	71.43	97.95	50	31	27.1	82.14	61.17	III	SlightlyPolluted
Lestari (w/o raining)	87.8	98.24	88.16	73.2	88.77	94.33	88.59	II	Clean
Football field (Raining)	65.42	99	59.48	59.94	78.85	61.24	71.68	III	Slightly Polluted

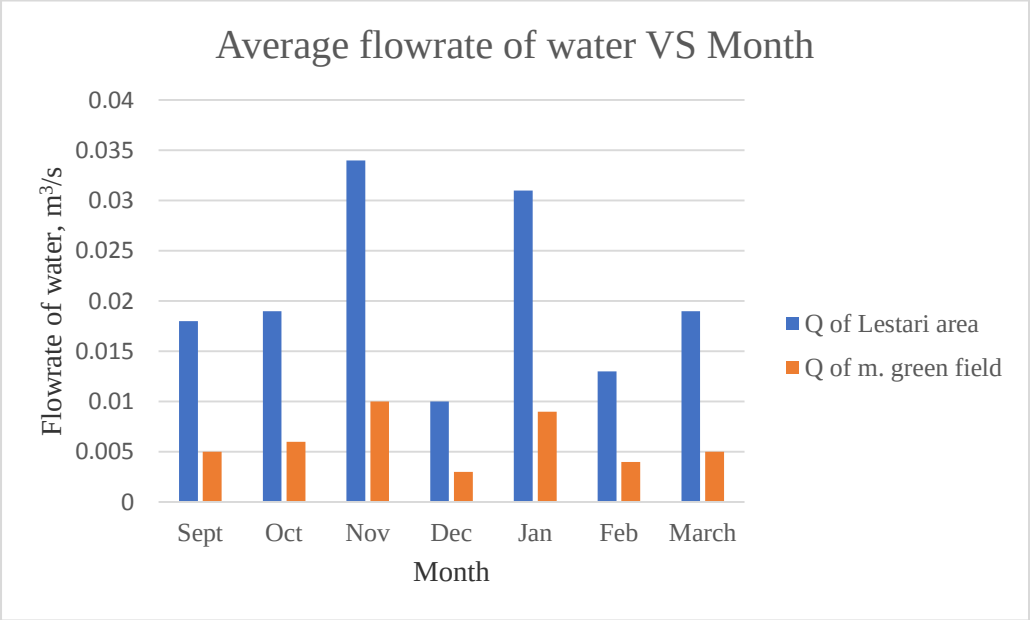

Fig. 6: Amount of water in both area

IV. CONCLUSION

UPNM campus is the zone that having variety of alternative water resource. Rainwater harvesting of pervious area at football field and ground surface water at Lestari hill are chosen as this time research. From these two locations, the effectiveness of selecting the location is in term of water quality and quantity. The quality of water before and after rainfall event are compared in both locations. Lastly, the best water quality is justified during the circumstance of sunny day in Lestari hill which no polluted and without the presence of coliform. Therefore, the water is suitable in toilet flush, car washing, watering the plant and others instead of drinking water if excessive water treatment is practising. The quantity of water is determined and estimated that the amount of water can be saved up until 5% if alternative water resource is practiced.

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