

Research Article

Qiong Sun*, and Zheng Liu

Impact of tourism activities on water pollution in the West Lake Basin (Hangzhou, China)

<https://doi.org/10.1515/geo-2020-0119>

received April 10, 2020; accepted September 30, 2020

Abstract: This paper introduced the development of tourism and its impact on the water environment. Then, taking the West Lake Basin as an example, the change of water quality in the basin between 2007 and 2018 and the changes of tourism population, tourism economic income, and tourism garbage between 2007 and 2018 through Hangzhou Tourism Bureau were investigated to analyze the impact of human tourism activities on the water environment of the West Lake Basin. The results showed that the change in curve trends of the comprehensive pollution index, number of tourists, tourism economic income, and tourism garbage in the West Lake Basin was similar, all rising; reasons for the increase of water pollution in the basin are that the increase in the number of tourists led to the increase of garbage and the government pursued the tourism economic benefits unilaterally and neglected the pollution brought by the tourism activities. Finally, we put forward three measures to reduce pollution.

Keywords: tourism activities, river basin water, pollution, impact

1 Introduction

Travel has gradually become a major choice for most people on holidays, and the tourism industry has also developed rapidly [1]. One of the purposes of travel is to relax, so the choice of tourist destinations is often those places with a beautiful environment [2]. Moreover, areas with rich natural resources are often more likely to become popular tourist attractions. Although the development of

tourism has promoted the economic growth to a certain extent, frequent human tourism activities inevitably cause different degrees of damages to the environment of tourist attractions. Especially when the tourism industry is just starting, due to the lack of management experience of local relevant departments and the unilateral pursuit of economic benefits, the tourism industry presents extensive development, and environmental damages to tourist attractions are large [3]. Especially for tourism that takes water resources as the development subject, the water environment is more easily affected by human tourism activities; therefore, it is more necessary to control the pollution degree of the water environment to ensure the normal development of tourism. Through the study of the impact of human tourism activities on the tourism water environment, it can provide a reference for the control of water pollution, improve the service quality of tourism, and maintain sustainable development. Yu et al. [4] investigated Shuifang Spring where the Jinfoshan holiday hotel is located through the high-resolution online tracing experiment and found that the fluctuation period of the groundwater chemical parameters of Shuifang Spring coincided with the peak period of tourism activities, which verified that tourism activities were the main reason for the change of groundwater chemical parameters of Shuifang Spring. The research of Ouattara et al. [5] shows that the implementation of ecotourism can maintain environmental quality. Based on the statistics of water environment pollution in the Dongjiang Lake scenic spot, Zhou and Xiong [6] conducted a quantitative research and analysis on its water environment capacity and then planned the scenic spot on this basis. Markogianni et al. [16] analyzed the impact of human activities, land utilization, and water and soil loss on the water quality of Plastira mountainous Mediterranean Lake and found from the final analysis results that human activities had a significant influence on the water quality of the lake, but with a low degree, the nutrient components in the water of the lake tended to be balanced, and water and soil loss had an influence on the phosphorus and iron balance of the lake. This paper briefly introduced the development of tourism and its impact on the water environment. Then, taking the West Lake Basin

* **Corresponding author: Qiong Sun**, Economy College, Beijing Technology and Business University, Beijing 100048, China, e-mail: sunqiongssq@163.com

Zheng Liu: Management College, Beijing Union University, Beijing 100101, China

as an example, it investigated the changes of water quality in the basin between 2007 and 2018 and the changes in tourism population, tourism economic income, and tourism garbage between 2007 and 2018 through Hangzhou Tourism Bureau, to analyze the impact of human tourism activities on the water environment of the West Lake Basin. The final results suggested that the composite pollution index of the West Lake showed an increasing trend, and the number of tourism, economic income, and a number of garbage all had significant impacts on the comprehensive pollution index of the West Lake. Finally, corresponding suggestions were put forward according to the analysis results.

2 Tourism and water environment

In the tourism industry, to improve the comfort of tourists in the process of tourism, the environment will be transformed in different degrees, and tourists will also produce different levels of pollutants in the process of tourism [7]. The water environment in the natural environment is relatively easier to be affected by human activities. Once the water environment is polluted, the first one to be affected is the aquatic organisms, and then, the land environment near the water environment watershed, which will affect the growth of surface organisms. If not prevented, the unsustainable development of tourist attractions will eventually lead to exhaustion of tourism resources and stagnation of tourism development [8].

The healthy development of tourism is the balance among environmental production, material production, and human production. Material production in tourism refers to tourism development based on the use of tourism resources in the natural environment and waste generated in the development process; human production in tourism refers to human tourism activities, economic benefits, and pollutants generated in the process; and environmental production in the tourism industry, especially the tourism with water environment as the selling point, refers to the water environment capacity for pollution and the provision of tourism resources under the natural and human influence [9].

The change in water environment has objective laws, but all kinds of human tourism activities will have an impact on the water environment at the same time (usually negative impact), and the change in water environment will react to human tourism activities. For example, if the water environment becomes more excellent, more tourists will be attracted to travel, and the economic benefits of tourism will be improved. If the water environment

becomes bad, tourists will not consider the tour of the place, tourism will be difficult to develop, and the local living environment will become worse [10].

3 Example analysis

3.1 Overview of the study area

The basic structure of the West Lake is shown in Figure 1. The West Lake is a famous tourist attraction in Hangzhou, Zhejiang province, China. It is surrounded by mountains on three sides, connected with the urban area on the East and Qiantang River on the south. The elevation of the hills around the West Lake increases outwards taking the West Lake as the center. The elevation of the hills is 50–400 m. The West Lake scenic spot is located on the northern edge of the subtropical zone, with an annual sunshine time of 1,800–2,100 h and a total radiation amount of 609–646 W/m². It is clear in all seasons, with obvious monsoon alternation and sufficient rainfall. As a tourist attraction, the West Lake also has rich tourism resources. In the West Lake scenic area, there are more than 20 kinds of mammals and 120 kinds of birds among the animal landscape resources. There are more than 100 scenic spots in the whole West Lake scenic area, including the Broken Bridge, Leifeng Pagoda, and Su Causeway. There are also quite rich myths and legends in the local area, which not only enriches the local cultural color but also adds a romantic atmosphere to the local scenic spots.

3.2 Investigation method of water environment and human tourism activities in the research area

The data used to reflect the human tourism activities in the West Lake scenic spot came from the tourism statistics of the Hangzhou Tourism Bureau of Zhejiang Province over the years. The relevant data content includes the number of people in the West Lake tourist area over the years (2007–2018), the economic income of the West Lake tourist area over the years (2007–2018), and the amount of tourism garbage generated by the tourists in the West Lake tourist area over the years (2007–2018). The relevant data are listed in Table 1.

The investigation method of the water environment in the West Lake tourist area was to conducting tests after

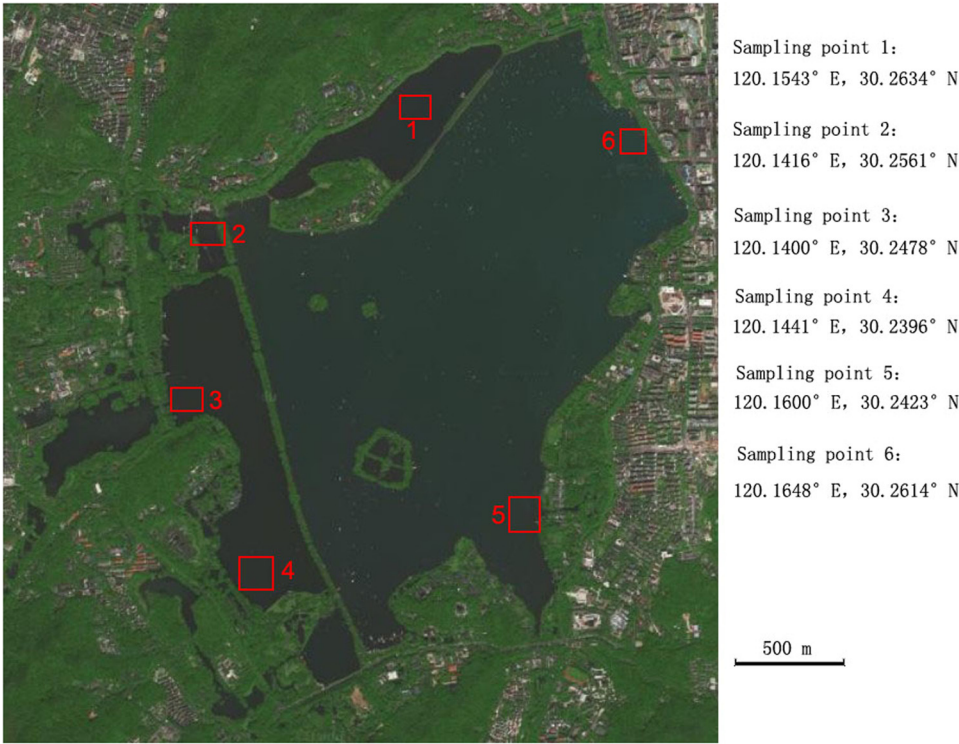


Figure 1: The West Lake in Hangzhou.

Table 1: The tourism statistics of the West Lake between 2007 and 2008

Year	Number of tourists/tens of millions	Economic income/ 100 million yuan	Economic income/ 100 million yuan	Year	Number of tourists/tens of millions	Economic income/ 100 million yuan	Economic income/ 100 million yuan
2007	0.8	1.2	0.5	2013	3.8	2.9	1.7
2008	1.3	1.6	0.6	2014	3.9	2.9	1.8
2009	2.2	1.9	0.8	2015	3.8	3.1	1.8
2010	2.5	2.3	1	2016	3.7	3.1	2
2011	2.1	1.9	0.9	2017	3.9	3.1	2.1
2012	3	2.4	1.3	2018	5.8	4	3.5

sampling at the West Lake sampling point. There were a total of six sampling points, and the locations of them are shown in the red box in Figure 1. The sampling points were set along the edge of the West Lake and near to the water inlet and outlet. The reason for the selection of the location is that the center of the West Lake is the key protection area, it is difficult to sample in the middle of the lake because of the large area, the edge of the West Lake, and the water inlet that are closer to the living area of the local people, and the tourism area can reflect the impact of local tourism activities on water quality effectively. An area with a size of 10 m × 10 m was divided from the sampling points in Figure 1, and the West Lake water

was sampled every 2 m, 2 L once. Then, the sampled water was detected using the following method:

- (1) The pH value of the sample was detected using a pH meter [11].
- (2) The suspended solids were detected using the weight method [12]. First, the mass of the dried filter membrane that has been dried to the constant weight was weighed, and then the sample was processed by extraction filtration using the filter membrane. The filter membrane was dried to the constant weight and cooled. The mass of the filter membrane after extraction filtration was recorded, so that the mass of suspended solids in the sample could be known. The content

of suspended solids in the drainage basin water was calculated [17].

- (3) The dissolved oxygen (DO) content in the sample water was detected by a DO meter.
- (4) The chemical oxygen demand (COD) content in the sample water was detected using the potassium permanganate method [13]. The sample solution was adjusted to acid using dilute sulfuric acid, then potassium permanganate solution was added. The mixture was heated in 70°C water bath for a period of time and then added with sodium oxalate standard solution while it was hot. Potassium permanganate titration was used, and the COD content was calculated according to the titration amount.
- (5) The content of ammonia nitrogen in the sample water was detected using the electrode method [14]: the sample water was taken and immersed in the measuring electrode; after the addition of NaOH–Na₂EDTA solution, the potential value was read while stirring, and the content of ammonia nitrogen in the sample was obtained referring to the standard curve.

After obtaining the detection indexes of the water sample, the water quality was evaluated using the comprehensive pollution index method [15], and the calculation formula is as follows:

$$\begin{cases} p_i = \frac{c_i}{c_{i0}} \\ p = \frac{\sum_{i=1}^n p_i}{n} \end{cases} \quad (1)$$

where n stands for the number of pollution detection indexes, p_i indicates the pollution index of the i th index, c_i represents the average value of the i th pollution index, c_{i0} is the standard evaluation of the i th pollution index, and p is the comprehensive pollution index.

3.3 Investigation results

The change in water quality pollution indexes of the West Lake Basin between 2007 and 2018 obtained by sampling and testing at six sampling points in the West Lake Basin is shown in Figure 2, and the specific data are shown in Table 2. It was seen from Figure 2 and Table 2 that the change in pH of the water quality of the West Lake Basin between 2007 and 2018 was in the range of 6.8–7.8, i.e., slightly acidic; the change in pH was relatively gentle before 2015, but significantly decreased after 2015; the

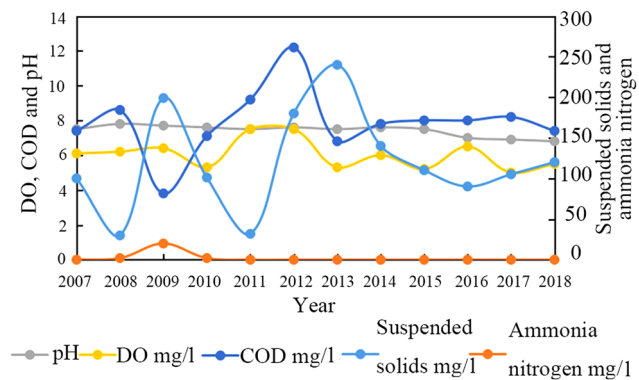


Figure 2: Changes in water quality pollution indicators in the West Lake Basin from 2007 to 2018.

Table 2: The water pollution index in the West Lake Basin between 2007 and 2018

Year	Suspended solids (mg/L)	Ammonia nitrogen (mg/L)	pH	DO (mg/L)	COD (mg/L)
2007	100	0	7.5	6.1	7.4
2008	30	2	7.8	6.2	8.6
2009	199	20	7.7	6.4	3.8
2010	101	2	7.6	5.3	7.1
2011	32	0	7.5	7.5	9.2
2012	180	0	7.6	7.5	12.2
2013	240	0	7.5	5.3	6.8
2014	140	0	7.6	6	7.8
2015	110	0	7.5	5.2	8
2016	90	0	7	6.5	8
2017	105	0	6.9	5	8.2
2018	120	0	6.8	5.5	7.4

Note: DO: dissolved oxygen; COD: chemical oxygen demand.

change in suspended solids in the water quality of the West Lake Basin between 2007 and 2018 was in the range of 30–240 mg/L, of which the content of suspended solids in 2009, 2012, and 2013 was significantly high, and the increase in amplitude was large, but after 2014, it showed a small decrease and then a small increase, showing an increasing trend overall; the change in ammonia nitrogen content in water quality was relatively stable; the fluctuation amplitude of DO content was relatively small. It was seen from Figure 2 that the fluctuation of the COD content was large, among which there was a large increase between 2009 and 2012, then a significant decrease and the change was gentle overall after 2014.

The above text shows the changes in water quality indicators in the West Lake Basin between 2007 and 2018. Although every indicator could reflect the quality of water quality in the basin to a certain extent, it was not

able to comprehensively evaluate the water quality of the basin alone. In particular, as shown in Figure 2, some indicators fluctuated violently, and some indicators were basically unchanged or changed slowly; therefore, it was difficult to directly see the overall water quality of the basin. Therefore, this study used the comprehensive pollution index to measure the overall pollution level of the water quality of the basin, used data such as the number of tourists, tourism economic income, and tourism garbage to reflect the human tourism activities, and analyzed the impact of human tourism activities on the water environment of the West Lake Basin based on the above two kinds of data.

As shown in Figure 3, with the increase of the year, the comprehensive pollution index of the West Lake Basin had a downward trend between 2010 and 2012 and between 2015 and 2016, an upward trend in other years, and an overall upward trend. The data in Figure 2 showed that the water quality of the West Lake Basin gradually changed from moderately clean (0.66) to moderately polluted (1.40). According to the tourism data statistics provided by Hangzhou Tourism Bureau, it was seen that the number of tourists traveling to the West Lake Basin increased from 2007 to 2018, but decreased significantly in 2011. The data showed that the number of tourists in the West Lake Basin gradually increased from

6.5 million to 28 million, and the economic income brought by tourism also increased in the corresponding years; although the change amplitude of the economic income was different from that of the number of tourists, the changing trend of the curves was quite close; especially in 2011, the tourism economic income decreased, and the data showed that the local tourism economic income gradually increased from 120 million yuan to 400 million yuan. The tourism waste generated by tourism activities had an upward trend in corresponding years, and the changing trend of the curve was quite close to the number of tourists, among which the tourism waste in 2011 declined, but not significant, and the data showed that the waste generated by tourism gradually increased from 50,00,000 to 3,50,00,000 *t*.

Although the change in the curves of the number of tourists, economic income, tourism garbage, and comprehensive pollution index of the West Lake in Figure 3 tended to be the same in trend and they could reflect the impact of human tourism activities on the water quality of the West Lake, it was not sure that the change of water quality due to pollution in the West Lake must be caused by human tourism activities. Therefore, to further verify the impact of human tourism activities on the water pollution of the West Lake, a correlation analysis was conducted on the number of tourists, economic income, tourism garbage, and comprehensive pollution index of the West Lake between 2007 and 2018. The results are shown in Table 3. It was seen from Table 3 that the number of tourists, economic income, and tourism waste had obvious correlations with the comprehensive pollution index, especially the number of tourists and tourism garbage, and all of the three indexes were in a positive correlation with the comprehensive pollution index.

The main reasons are as follows: (1) The increase of the number of tourists in the West Lake was equivalent to the increase of the local population density in a short period of time, which not only exceeded the local environmental bearing range but also increased the generation of tourism garbage, which led to the increase of water pollution in the basin. It was the reason why the number of tourists and tourism garbage had a significant

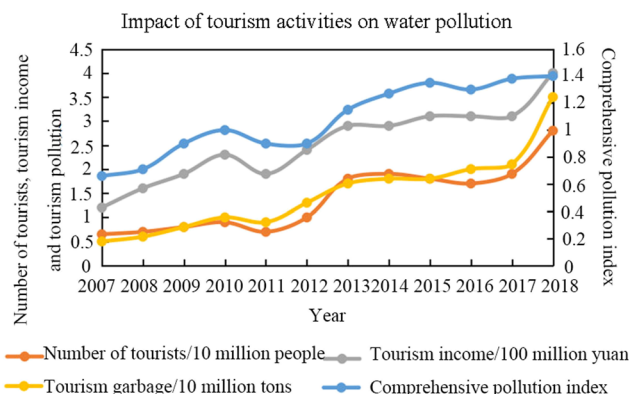


Figure 3: Human tourism activities and the change of comprehensive pollution index of water environment in the West Lake Basin.

Table 3: The correlation between human tourism activities related data and the comprehensive pollution index of water quality in the West Lake

	Number of tourists	Tourism economic income	Tourism garbage
Comprehensive pollution index	1.213**	1.874*	1.545**

Note: ** and * indicate $P < 0.01$ and 0.05 respectively, i.e., difference had statistical significance.

correlation with the comprehensive pollution index. (2) Facing the good tourism economy brought by the West Lake, the government ignored the pollution brought by tourism and carried out unscientific planning; in the process of the construction of tourism facilities, it would also bring considerable water pollution. It was the reason why tourism economic income had a significant correlation with the comprehensive pollution index.

3.4 Discussion and analysis

As shown in the above survey results, the comprehensive pollution index of the water environment of the West Lake Basin generally showed an increasing trend between 2007 and 2018, although there was a decrease in some years, i.e., the water environment of the West Lake Basin was gradually getting worse. Besides the objective changes caused by climate and other natural reasons, the pollution of human tourism activities to the water environment is a major reason, which was also found by the above data survey on tourism activities. The high-quality tourism resources of the West Lake attracted a large number of tourists, and the number of tourists is increasing year by year, which makes the local tourism economy also to increase, but it is also the growth of the number of tourists that makes the garbage generated in the process of tourism increase, which increases the pollution in the river basin water. Moreover, the growth of the number of tourists also brings the growth of the economic income, which makes the government pay more attention to the economic benefits and ignore environmental protection. The expanded construction of tourism facilities will also cause pollution to the West Lake.

To reduce the impact of human tourism activities on the water environment of the West Lake Basin, the following measures are proposed:

- (1) Tourists need to be diverted to reduce the situation of excessive population density in a single period of time. The increasing number of tourists is a phenomenon caused by the improvement of people's living standards, which is hard to inhibit. In the West Lake tourist area, there are peak season and offseason. Usually, there are many tourists in the peak season; therefore, tourism activities are frequent and pollution is more serious. Thus, we can reduce the density of tourists in a single period and reduce the burden of the water environment in the West Lake Basin by diverting the tourists in the peak season to the offseason period. The means of diversion include increasing

ticket prices in the peak season and offering high discounts in the offseason.

- (2) The awareness of tourism environmental protection should be strengthened. In addition to the unavoidable pollution caused by a large number of people, the main reason for the severe pollution is the low environmental awareness of tourists themselves. Therefore, in the West Lake tourist area, relevant departments need to strengthen the environmental protection publicity for tourists and reduce the impact of pollution on the water environment from the source.
- (3) The scientific planning of tourism facilities is needed. To ensure the sustainable development of the water environment in the West Lake Basin, the existing tourism facilities that do not conform to the scientific planning shall be demolished, and the original ecological environment shall be restored as much as possible. Moreover, in response to the growing tourism population, the new tourism facilities shall be planned scientifically to reduce the pollution of the water environment during the construction process as much as possible.

4 Conclusion

This paper introduced the development of tourism and its impact on the water environment. Then, taking the West Lake Basin as an example, it investigated the change of water quality in the basin between 2007 and 2018 and the changes of tourism population, tourism economic income, and tourism garbage between 2007 and 2018 through Hangzhou Tourism Bureau, to analyze the impact of human tourism activities on the water environment of the West Lake Basin. The results are as follows. With the increase of the year, the changing trend of the curves for comprehensive pollution index, number of tourists, tourism economic income, and tourism garbage in the West Lake Basin was similar, and the overall trend was upward. According to the analysis, the reason for the increase in water environment pollution in the West Lake Basin was related to human tourism activities. The main reason was that the increase in the number of tourists made the local population intensive, and the garbage generated by tourism increased, which exceeded the bearing capacity of the water environment. The government departments pursued tourism economic benefits unilaterally and ignored the pollution caused by tourism activities. To reduce the impact of tourism activities on

the river basin water environment, several measures were put forward, including time division of tourists, strengthening the publicity of tourism environmental protection, and scientific planning of tourism facilities.

Abbreviations

COD chemical oxygen demand
DO dissolved oxygen

Acknowledgments: This work is supported by research grants from the Beijing Philosophy and Social Science Foundation Federation [Grant No. 19GLC054].

References

- [1] Referowska-Chodak E. Plans for the development of infrastructure and tourism activities in landscape parks under the State Forests' administration. *For Res Pap.* 2016;76(4):377–87.
- [2] Mihaila D, Bistricean PI, Ilies A, Paiusan FO, Gale M, Sipos L. et al. Moneasa balneoclimatic resort between shelter bioclimate and bad weather. *J Environ Protect Ecol.* 2019;20(4):1745–53.
- [3] Aktas NK, Donmez NY. Effects of urbanisation and human activities on basin ecosystem: Sapanca Lake Basin. *J Environ Protect Ecol.* 2019;20(1):102–12.
- [4] Yu ZL, Yuan DX, Yang PH, Li LL, Xie SY. Influences of tourism activities on hydrochemistry of karst groundwater revealed by principal component analysis and on-line monitoring technique. *Acta Geosci Sin.* 2016;37(2):232–40.
- [5] Ouattara B, Pérez-Barahona A, Strobl E. Dynamic implications of tourism and environmental quality. *J Public Econ Theory.* 2019;21(2):241–64.
- [6] Zhou ZX, Xiong XY. Study on the water environmental capacity of Dongjiang Lake Scenic area. 2015 International Conference on Energy, Environmental & Sustainable Ecosystem Development; 2015.
- [7] Ying AN. Tourism development and ecological environment protection. *J Landsc Res.* 2015;7(1):43–4.
- [8] Mohamad D, Bahaiddin A, Mohamed B. Tourism development progress of two islands of Malaysia: The locals' perspective towards climate change. *Worldw Hosp Tour Themes.* 2016;8(5):534–48.
- [9] Shiji M, Sabitha AR, Prabhakar K, Harikumar PS. Water quality assessment of Kavyai Lake of northern Kerala, India using CCME water quality index and biological water quality criteria. *J Env Biol.* 2016;37(6):1265–72.
- [10] Zhang SS, Zhang LC, Dong YW, Yang YK. Selecting industries based on evaluation of the water environment's carrying capacity: A case study of the Northern Lakeside Region of Yangzhou City. *Acta Ecol Sin.* 2017;37(17):5853–60.
- [11] Liu HM, Yang SD, Gao Y, Li XJ. Qianjiang zhuowater scenic mountain national regions inclusive path of tourism development. *Heilongjiang Agric Sci.* 2016;09:92–96.
- [12] Nejati M, Mohamed B, Omar SI. The influence of perceived environmental impacts of tourism on the perceived importance of sustainable tourism. *E-rev Tour Res.* 2015;12(1/2):99–114.
- [13] Tamelan PG. Geophysical characteristic and water resources availability in Rote Ndao, East Nusa Tenggara as a basic for coastal tourism development. *J Ind Tour Dev Stud.* 2015;3(2):69–74.
- [14] Shepherd J. A land apart: The southwest and the nation in the twentieth century by Flannery Burke (review). *Southw Historic Quart.* 2018;121(4):469–70.
- [15] Geismar H. Patina: A profane archaeology by Shannon Lee Dawdy. *Anthropol Quart.* 2017;90(2):543–8.
- [16] Markogianni V, Mentzafou A, Dimitriou E. Assessing the impacts of human activities and soil erosion on the water quality of Plastira mountainous Mediterranean Lake, Greece. *Env Earth Sci.* 2016;75(10):915.1–17.
- [17] Aisyah COS, Faizal WIW, Adam AM, Siddiqi IA, Siddiqi SN. Development of water quality modelling using InfoWork river simulation in Malacca River, Malaysia and contribution towards total maximum daily load approach. *Iop Conf.* 2018;169:012073.