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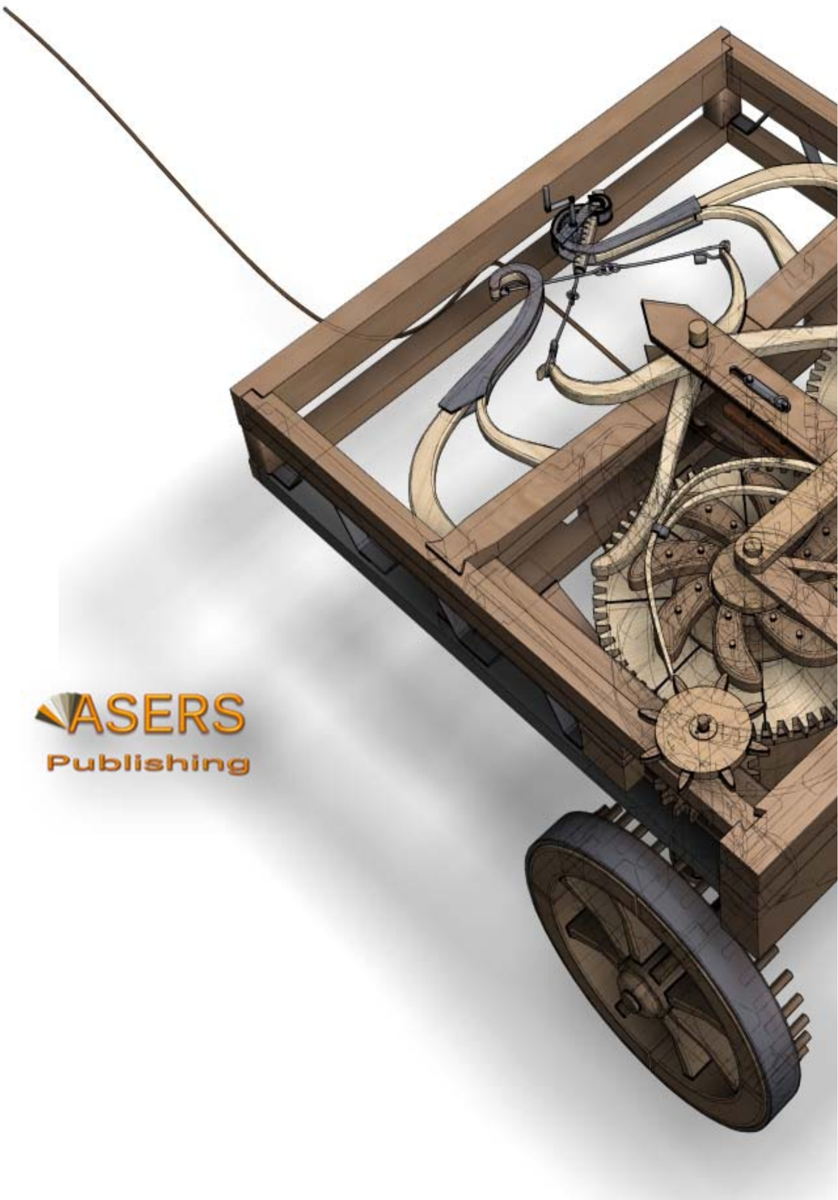

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Alteration of Spatial Pollution Compounds to Eutrophication Phenomenon of Small-Scale Area under Corona Virus Disease Circumstances

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Abstract:

This research aims to study the alteration of spatial pollution compounds to the eutrophication phenomenon in water resources during the COVID-19 situation. Sixteen water resources were monitored to examine the impact of spatial pollution compound on eutrophication phenomenon discovered from the activities of the Valaya Alongkorn Rajabhat University under the Royal Patronage. The analytical parameters were DO, nitrite (NO_2^-), nitrate (NO_3^-), ammonia (NH_3), phosphate (PO_4^-), and Total kjeldahl nitrogen (TKN) collected in three months (November 2020, January 2021, and March 2021). This research has presented the differences in water resource characters in three months and the positive impact of the COVID-19 lockdown on wastewater. The total nitrogen was highest in November 2020 when compared with that of in January and March 2021 because it was a 'normal situation' (no lockdown) in November. The student, officer, lecturer, and government visitors came to use the facilities of the university. The results of total kjeldahl nitrogen showed a high range during the working period. The effect of P was higher on the water bodies in November than January and March because in November was a normal situation (no lockdown). The N:P ratio showed different trends to the eutrophication phenomenon with nitrogen and phosphate. Therefore, a comparison between a situation with lockdown and no lockdown showed that the lockdown situation was environment friendly. Finally, the results also confirm an improvement in environmental quality, which happened when humans were absent, especially in coronavirus circumstances.

Keywords: spatial pollution; wastewater; environment; eutrophication phenomenon; COVID-19 circumstances.

JEL Classification: Q53; Q51; Q56.

Introduction

The global population is expected to grow, increasing industry, agriculture, and households (Spångberg 2014). Human activities are increasing with population growth, accompanied by increased water use. This growth will not only severely reduce water availability per person but also create anxiety on biodiversity in the entire global ecosystem (Wang *et al.* 2021). The daily water used by humans and in the ecosystem depends on surrounding water quality. The growing modernized agriculture techniques, urbanization, and increasing population play a considerable role in the quality of water and having harmful effects on neighboring watersheds (Popradit 2017; (Jung *et al.* 2021). Although water is considered a renewable resource, it is affected by crops and livestock, agricultural production and use of chemical fertilizers, the high nutrients in urine and faeces or household activities, hazardous and industrial waste. The wastewater discharge from those activities contains a high amount of toxicity that affects the freshwater quality (Wang *et al.* 2021). Nowadays, water resources are being diverted for agricultural, domestics, and industrial uses. The water resources should be more efficiently used, water-saving efforts should be promoted, and water demands should be controlled. The concentrations of pollutants in surface water and the river water quality variations are mainly influenced by domestic sewage, industrial wastewater, brine intrusion, drainages from cultivated land, and livestock farms (Biondo *et al.* 2021). The high amount of nutrients consisting of N and P compounds from the agricultural areas and domestic wastes can lead to eutrophication, which results in the rapid growth of algae, leading to the lowering of dissolved oxygen into the water. With high nitrate, aquatic plants and algae are overproduced, which causes the settling of dead algae and macrophytes at the bottom of the water system (Yan *et al.* 2021). Chemical oxygen demand (COD) is also one of the important indicators that help monitor such processes that can lead to eutrophication (Ngatia *et al.* 2019).

Nitrates come to soil either naturally or from municipal waste, industrial waste, decomposition of both plants and animals, and fertilizers (Zhao 2015). P mining from P rocks and P fertilizer is a cause of water pollution. Too much N and phosphorous in water cause algae to grow and lead to the eutrophication phenomenon (Verma *et al.* 2014). Va *et al.* (2018) reported that domestic wastewater generated from various types of buildings had been recognized to be different to some extent. The study aimed to know the quality, quantity, fluctuation of domestic wastewater released from office buildings. The sample was measured by parameters using a standard method. The study concluded that domestic wastewater from buildings has specific characteristics, and it contains a high concentration of the nutrient. Roy (2019) reported that poor quality water was a threat to the water ecosystem and may cause hazards and severe economic loss. This analysis involved some standard protocols. This research provided guidelines for sampling preservation and analysis of the samples. It also briefly discussed a standard chain of action that can help the analysis. This study systematically analyzed different classification methods of the service function of water ecosystems that affect it. The study focused on water resource protection, allocation, utilization, and the impacts of water resources management.

Water pollution has become a challenging problem all over the globe, causing a scarcity of useful water. Therefore, there is a pressing demand to develop an eco-friendly environmental policy. However, higher education institutions are change agents in society, and they require services from their communities and leaders in social responsibility and ecological sustainability (Tangwanichagapong 2017). Therefore, this research aims to study the alteration of spatial pollution compounds to the eutrophication phenomenon in water resources during the COVID-19 situation. This research study period was selected in accordance with the opening and closing of the university office under the COVID-19 pandemic (Qiao *et al.* 2021). We concluded the study relating the problem of water quality in Valaya Alongkorn Rajabhat University under the Royal patronage (VRU) and investigated the water quality at the critical station. Finally, this study will identify the variations of pollution compounds to the eutrophication phenomenon in university. Moreover, the results can also confirm an improvement in environmental quality, which could happen when humans are absent, especially in coronavirus circumstances.

1. Methodology

1.1 Study Site and Sampling Stations

The 16 research stations are around the area of VRU. Because VRU is in Pathum Thani province, a wetland area, at an altitude of 5–10 meters above sea level. In the context of the Chao Phraya River Basin, this area was a flood plain in the past. Therefore, the construction of the buildings or large structures was necessary to create a sufficient drainage source for the rainy and flood season. For this reason, VRU has many drainage sources, and they are interconnected and connected to the natural canal outside (Figure 1).

Figure 1. Water resource stations in the university.

A rough detailed description of each station as follows (Figure 2).

Figure 2.The stations of water resources in the university

Station 1 Sewerage ditch from office building related to university restaurant.

Station 2 Sewerage ditch from an office building that is connected to the university Science centre building.

Station 3 Sedimentation pond around the demonstration school.

Station 4 Big pond in front of Thai traditional house connected to the office building, demonstration school.

Station 5 Excavated canal connected to VRU coffee shop; it connects to the natural canal outside VRU.

Station 6 Excavated canal around university dormitory; obtains wastewater from the dormitory.

Station 7 Excavated canal around demonstration school; it connects to the natural canal outside VRU.

Station 8 and 9 Sedimentation ponds behind and in front of the university dormitory.

Station 10 Sedimentation pond opposite to dormitory and canteen.

Station 11 Sedimentation pond behind football field and connected to university personnel housing.

Station 12 Sewerage ditch connected to agricultural demonstration area of VRU.

Station 13 Big pond close to agricultural demonstration area of VRU.
Station 14 Big pond behind the faculty building.
Station 15 Big pond behind the faculty building.
Station 16 Big pond that nearly the buffalo shelter.

1.2 Research Design

Wastewater samples were collected from November 2020 to March 2021 in 16 stations (Figures 1 and 2). They were gathered in bottles and stored in laboratory refrigerator at 4 °C before being measured. Some parameters were measured in situ using hand-held probes (DIGICON WA-48SD) to characterise pH and DO. The 6-chemical property of wastewater is shown in table 1.

Table 1. Chemical property parameters in this research

Parameters	Unit	Months	Method
DO	mg L^{-1}	1st, 2nd, 3rd months	APHA, 23nd edition (APHA, 2017)
Nitrite (NO_2^-)	mg L^{-1}	1st, 2nd, 3rd months	APHA, 23nd edition (APHA, 2017)
Nitrate (NO_3^-)	mg L^{-1}	1st, 2nd, 3rd months	APHA, 23nd edition (APHA, 2017)
Ammonia (NH_3)	mg L^{-1}	1st, 2nd, 3rd months	APHA, 23nd edition (APHA, 2017)
P (PO_4^-)	mg L^{-1}	1st, 2nd, 3rd months	APHA, 23nd edition (APHA, 2017)
Total Kjeldahl N (TKN)	mg L^{-1}	1st, 2nd, 3rd months	APHA, 23nd edition (APHA, 2017)

1.3 Statistics

The data were basically analysed with Microsoft Excel. The examination of the impact of spatial pollution compounds on the eutrophication phenomenon in small-scale water resource of university area was conducted under the circumstances of COVID-19. The two-sample tests were used, and statistical significance was determined with the 2-way ANOVA ($p < 0.05$). The statistical treatments were conducted with MINITAB (ver. 17, Kozo Keikaku Engineering Inc., Tokyo, Japan)

1.4 Eutrophication phenomenon analysis

This research was calculated cumulative of N and P with mass balance calculation. The ratio of N and P accumulation showed the water resource was occurred the eutrophication phenomenon from N or P. The equation for calculation as follow Eq. 1.1:

$$R = \frac{[TN]}{[OPO_4P]} \quad 1.1$$

where: [TN] is TN in water resource (mg L^{-1})
[OPO_4 P] is ortho P level in water resource (mg L^{-1})
R > 10: High N, P is limiting factor for the eutrophication phenomenon.
R < 5: High P, N is limiting factor for the eutrophication phenomenon.

The eutrophication phenomenon is occurred with high N or high P in water resource. N and P are high nutrient that release from human activities. High levels of N and P are harmful and nutrient runoff causes overgrowth of algae or microorganisms. The ratio of N to P compounds in water resource is important factor that limiting factor and consequently that controlled to reduce algae bloom. Moreover, the ratio of N to P and algae cell can be predicted the eutrophication phenomenon. The N to P ratio was 7:1 and algae cell (Table 2) that can result to eutrophication phenomenon occurred.

Table 2. Eutrophication phenomenon from nutrient concentration

P (mg L^{-1})	N (mg L^{-1})	Dry algae cell (mg L^{-1})	Significant
0.013	0.092	1.45	Problem threshold
0.13	0.92	14.50	Problem likely to exist
1.30	9.20	745	Severe problems possible

Source: EPA, 1985; 2001

2. Results and Discussions

2.1 The Impact of Spatial Pollution Compound to the Eutrophication Phenomenon

There are many water resource stations in the university. Each water resource obtained wastewater from each building, canteen, and a small community in the university. Generally, the characteristics of the wastewater in

VRU are similar to municipal wastewater, especially the N and P content. The nitrification and denitrification processes can convert the N compound into ammonia, nitrite, and nitrate. Thus, nitrification and denitrification processes can help reduce N compounds, leading to a decrease in the eutrophication phenomenon in water resources. There are 2 steps of the nitrification process: *Nitrosomonas* sp converts NH_3 into nitrite, and then *Nitrobacter sp* oxidizes NO_2^- into NO_3^- as shown in Eq 2.1 and 2.2:

$$NH_3 + O_2 \longrightarrow NO_2^- + H_2O + H^+ \qquad 2.1$$

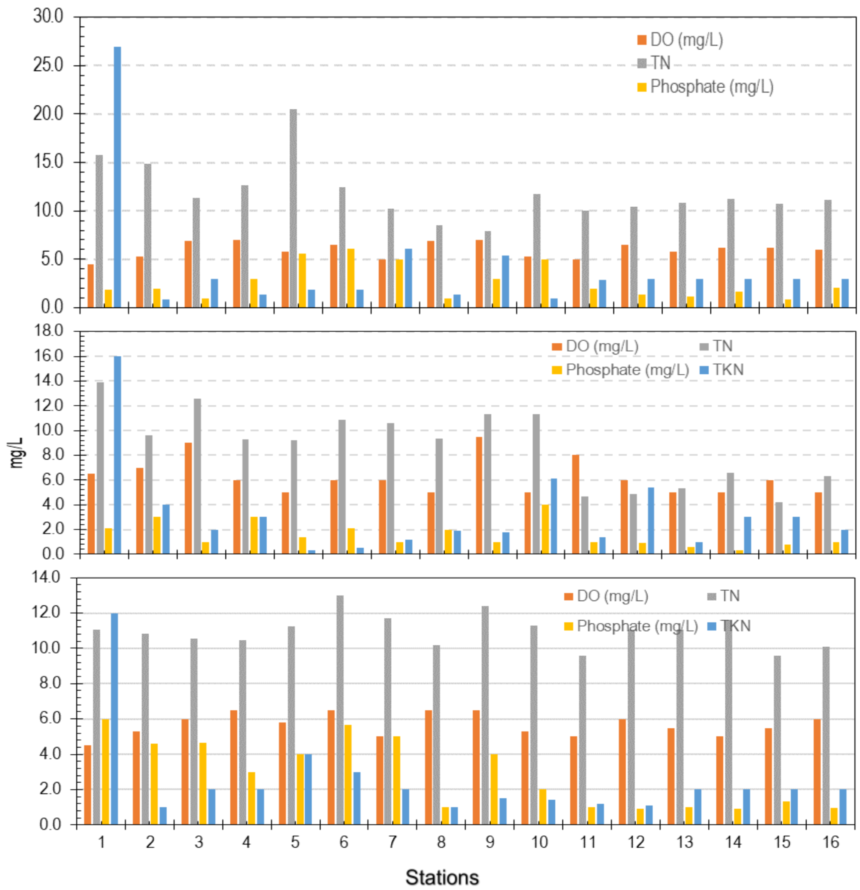
$$NO_2^- + O_2 \longrightarrow NO_3^- \qquad 2.2$$

The denitrification process is the opposite of the nitrification process. This process is a reduction process. It occurs under anaerobic conditions when oxygen levels are depleted. The nitrate becomes the primary oxygen source for microorganisms. Nitrate is converted into gaseous N compounds, such as N_2O, NO, and N_2, by different bacteria, such as *Bacilius* sp., *pseudomonas* sp., *clostridium* sp. In this process, nous compounds follow the chain of Eq 2.3.

$$NO_3^- \longrightarrow NO_2^- \longrightarrow NO \longrightarrow N_2O \longrightarrow N_2 \qquad 2.3$$

DO is another factor that affects the nitrification and denitrification processes because the nitrification process occurs in aerobic conditions (Equation 1–2). When nitrification can not happen, it leads to the accumulation of N compounds in water resources. N compound and also P compound are nutrients for plant and algae growth. A high amount of nutrients results in excessive plant and algae growth, covering the top of water resources. As a result, oxygen cannot get dissolved into the water bodies. DO affects aquatic animals because they use gills for breathing. If oxygen cannot be dissolved into the water body, the aquatic animals face shortness of breath and death. This research measured DO in water resources within the three-month study period (November 2020, January 2021, and March 2021) (Figure 3 A, B, C). The November 2020 data show DO range was between 4.5 and 7.0 mg L^{-1}, while DO in January 2021 was between 5.0 and 9.0 mg L^{-1}. The DO of March 2021 was within the range of 4.5 – 6.5 mg L^{-1} because of the increase in the number of people.

Figure 3. Analytical parameters in each station in three months; November 2020 (top), January 2021 (middle), and March 2021 (bottom)



Total Nitrogen (TN) included ammonia (NH_3), nitrite (NO_2), and nitrate (NO_3). TN in November 2020 was 7.9 to 20.5 mg L^{-1} (Figure 3 A, B, C); 4.7 to 13.9 mg L^{-1} in January 2021 (Figure 3 A, B, C); and 11.0 to 13.0 mg L^{-1} in March 2021 (Figure 3 A, B, C). In November 2020, TN was maximum because it was the so-called 'normal situation' (no lockdown) when students, officers, lecturers, and government visitors came to use the university facilities. January 2021 marked the beginning of the lockdown period under the COVID-19 crisis, and March 2021 represented the period when the university opened with 'new normal' protocols. TKN is organic N in the water bodies. TKN in November 2020 was from 0.9 to 26.9 mg L^{-1}. It was 0.3 to 16.0 mg L^{-1} in January 2021 and 1.0 to 12.0 mg L^{-1} in March 2021. The results show that TKN was in a high range during the working period. P in November 2020 was 1.9 to 6.1 mg L^{-1} (Figure 3 A, B, C); in January 2021, it was 1.0 to 4.0 mg L^{-1} (Figure 3 A, B, C); and in March 2021, it stood somewhere between1.0 and 6.0 mg L^{-1} (Figure 3 A, B, C). P is a component in found detergent and cleaning agents that are released into water bodies. It is hard for ordinary wastewater systems to break it down. Therefore, P has appeared in the water bodies. For this situation, P in January 2021 was lower than those of November 2020 and March 2021 because of the COVID-19 lockdown.

The amounts of TN and P were significantly high between the month (Figure 4). TN was particularly high in November 2020 and March 2021, while very low in January 2021. Figure 5 shows that P and TKN were significantly high between months, especially in station1 (Figure 5).

Figure 4. Boxplot of TN (mg L^{-1}) and P (mg L^{-1}) versus month

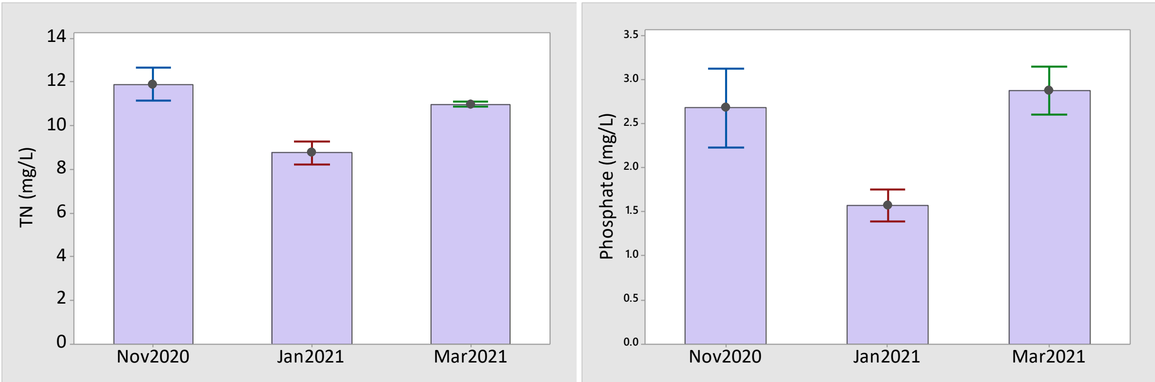
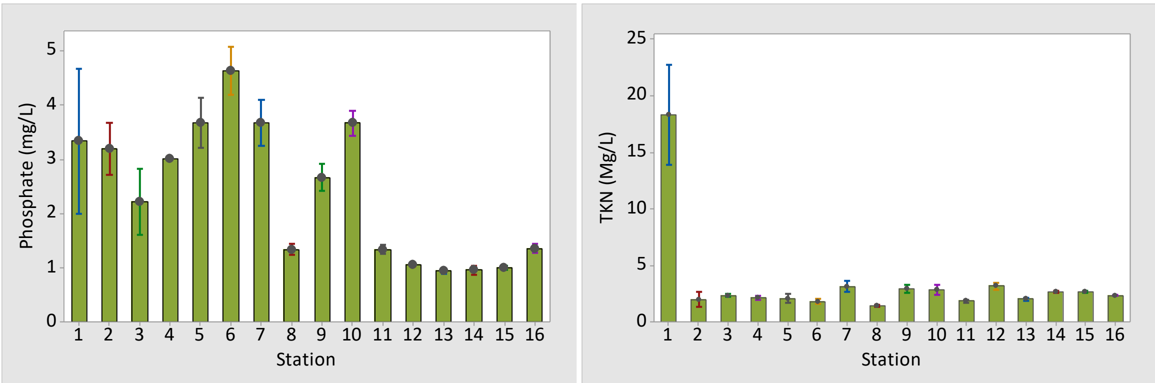


Figure 5. Boxplot P (mg L^{-1}) and TKN (mg L^{-1}) versus station

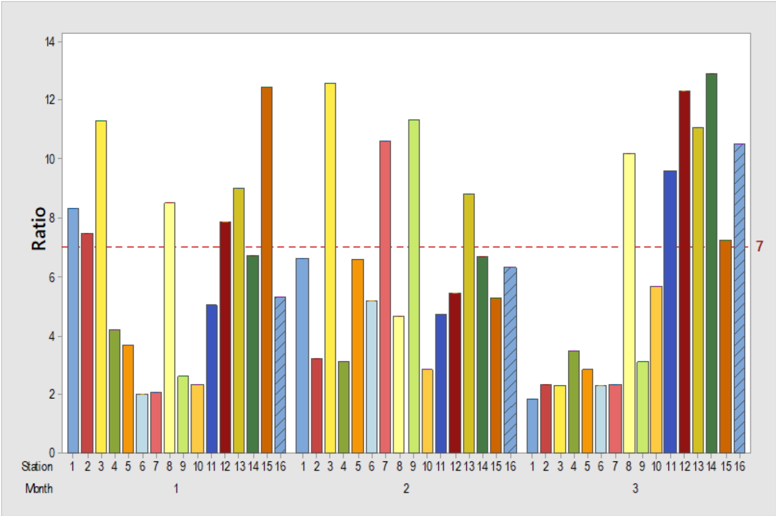


2.2. Eutrophication Phenomenon Analysis

The eutrophication phenomenon occurred in November 2020 at 7 stations and in March 2021 at 6 stations during normal situations (no lockdown). We found that only 4 stations had eutrophication phenomenon during January 2021. In stations 12, 13, 14, the ratio of N:P was consistently high during the experimental period. It could be concluded that VRU should be concerned with the water quality of those stations (Figure 6).

In station 12, the sewerage ditch is related to the agricultural demonstration area of VRU. There are many types of agricultural activities. The N:P ratio in March 2021 was as high as 12.30:1, and N was the limiting factor. Station 13 is a big pond close to the agricultural demonstration area of VRU. The ratio was high every month. Here, too, N was the limiting factor.

Figure 6. The N:P ration with reference line (7:1), the probability of eutrophication phenomenon nutrient concentration in VRU



Station 14 is a big pond behind the faculty building. It had a very high N:P ratio. Note that these 3 stations are 1 sewerage ditch and 2 big ponds. DO and light are also important factors to the eutrophication phenomenon. The light and DO conditions should be suitable for eutrophication. VRU should be more concerned with these 3 stations as much as we are.

Conclusion

Due to increasing population, economic development, and increasing human activities, such as fertilisation and agricultural activities, sewage and industrial runoff that contribute global water pollution, the process of eutrophication can be greatly accelerated (Yang *et al.* 2021). The two most critical phenomena of eutrophication are lack of oxygen and algal blooms that produce harmful toxins, processes that can destroy the aquatic ecosystem. When eutrophication occurs, the chemical composition of the water changes. There may be excessive alkalinity during intense photosynthesis, causing ammonia toxicity in fishes (Li *et al.* 2021). During the later stages of eutrophication, the water body is supported by abundant plant life due to the higher availability of nutrients, such as N and phosphorous (Khan and Mohammad 2014). These can be short-term problems, but they will contribute to long-term environmental issues like climate change, ocean warming, acidification, and major ecological impacts on the aquatic ecosystem and surface water (Jia *et al.* 2019). Management should focus on increasing the concentration of nutrients released from human activities (Jessen *et al.* 2014). The study period of each station was three months, wherein the second month (January) was lockdown for COVID-19. However, ecosystems are changing dramatically due to climate change. The restriction of lockdown played a positive role in recovering the health of the environment when the university was closed, and the students had chosen to remain in their homes, avoiding public activities and classes in the university.

Finally, this research will recommend that the management of green organizations positively impact their journey towards a sustainable environment.

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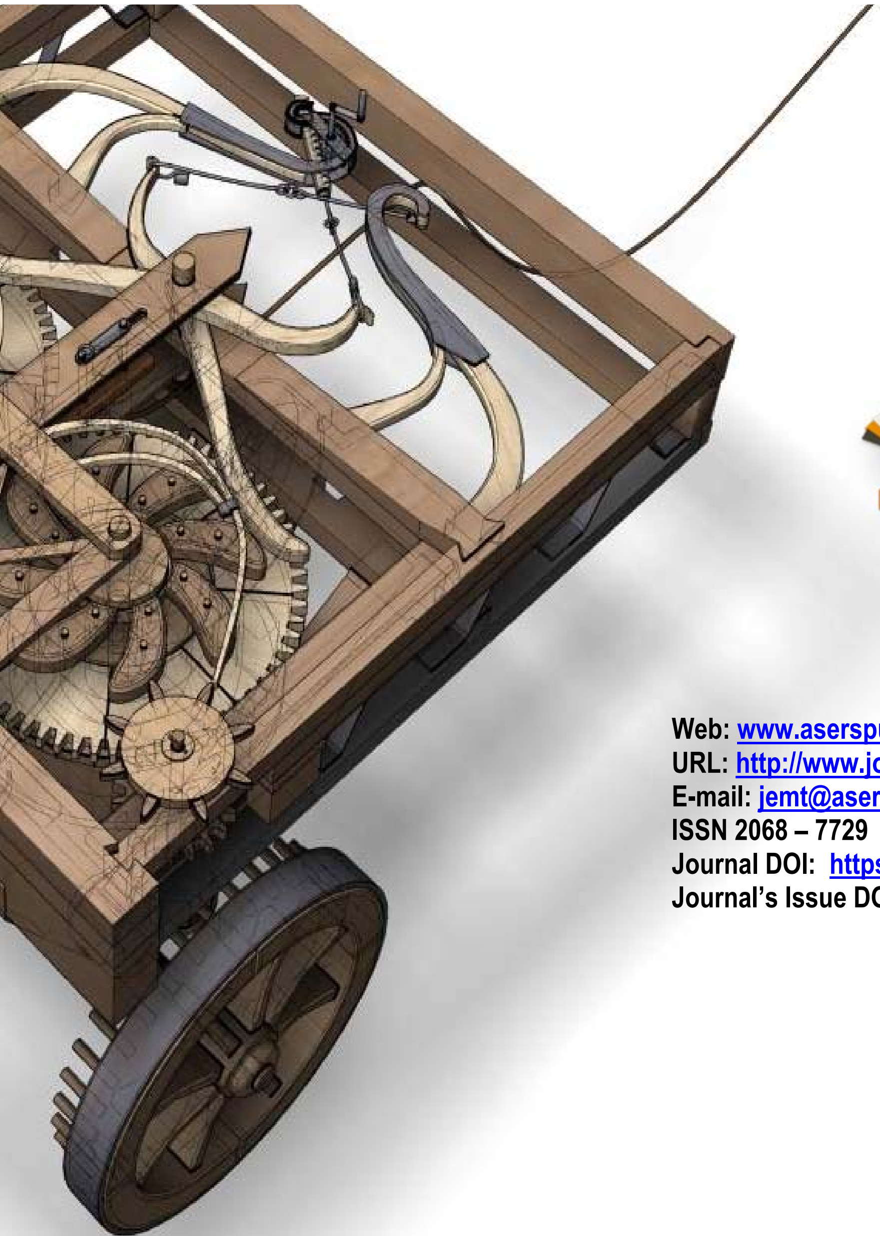

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