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WATER QUALITY ASSESSMENT OF WULAR LAKE: MONITORING POLLUTION LEVELS AND RAMSAR CONVENTION COMPLIANCE

Dr. Ishfaq Majeed Malik

Department of Environmental Science,

Shri Jagdishprasad Jhabarmal Tibrewala University,

Jhunjhunu, Rajasthan, India

ABSTRACT

The Kashmir Valley in India is home to Wular Lake, which has the differentiation of being the greatest freshwater lake in Asia and a significant part of the wetland climate. The Ramsar Show, which is a global show for the assurance and maintainable utilization of wetland regions, recognizes the natural worth of Wular Lake. This study article gives a nitty gritty assessment of the water nature of Wular Lake, with a specific accentuation on checking the degrees of contamination and deciding if the lake consents to the prerequisites laid out by the Ramsar Show. Examination of a water quality informational collection comprising of 27 boundaries was performed utilizing multivariate procedures, discriminant examination, and water quality file (WQI) at five unique areas inside Lake Wular in Kashmir Himalaya between the years 2011 and 2013. The reason for this examination was to research spatiotemporal varieties and distinguish likely wellsprings of contamination. Using stepwise discriminant examination, a few water quality measurements were dissected concerning their spatial and fleeting changes (DA). It was shown that the first spatial discriminant capability (DF) was liable for 76.5 percent of the generally speaking spatial variety, though the second DF was answerable for 19.1 percent of the noticed difference. The mean upsides of water temperature, electrical conductivity (EC), complete nitrogen (TN), potassium (K), and silicate played a huge part in recognizing the five example areas. A huge commitment was made by the mean convergence of NO2-N, all out N, and sulfate in recognizing the four example seasons. Besides, these fixations represented most of the occasional variances that were expected.

Keywords: *WQI, Wular Lake, Kashmir, Pollution, Ramsar Convention*

I. INTRODUCTION

Because of its simple openness for the unloading of poisons and wastewaters, surface water is presently the most vulnerable to defilement. Complex anthropogenic exercises and regular cycles [1, 2] are liable for deciding the nature of surface water all over the planet. These cycles incorporate enduring, disintegration, hydrological highlights, environmental change, precipitation, modern exercises, farming area use, sewage release, and the human abuse of water assets [1-6]. It has been seen that the quick development of industry, horticulture, and endless suburbia has brought about a broad corruption in the water nature of inland sea-going frameworks throughout the span of the last ten years [7-9]. During the most recent couple of years, the evaluation of water quality has turned into a critical subject in most of countries. This is especially attributable to the way that there are fears that freshwater will be a restricted asset later on [10, 13]. Because of the restricted stockpile of new water and the job that human exercises play in deteriorating the water quality, the preservation of the uprightness of the world's water assets has been alloted the most noteworthy need in the 21st century [14-17]. Regardless of this, it is preposterous to expect to do this without first leading a spatiotemporal evaluation of the water nature of the sea-going frameworks that are of interest [18]. The reasons for contamination, as well as the potential effects of normal cycles and human exercises on spatiotemporal changes in water quality, have been perceived by countless examinations [19, 20].

In light of the geological and worldly vacillations in the hydrochemistry of surface waters, it is important to have successive observing frameworks set up to give precise assessments of the water quality [12]. Checking the nature of water is a helpful instrument that can be utilized not exclusively to survey the impacts of contamination sources yet in addition to ensure the successful organization of water assets and the conservation of sea-going life [21]. Nonetheless, the enormous and convoluted informational indexes of water quality boundaries that are produced by checking programs are much of the time challenging to decipher idle significant data [11, 12, 22, 23]. These informational indexes require information decrease techniques to work on the information structure to extricate data that is both valuable and interpretable [24]. Because of this test, the use of multivariate factual and numerical methods, for example, discriminant examination (DA) and water quality file (WQI), makes it simpler to decipher complex information frameworks to acquire a more profound understanding of the water quality and natural status of the frameworks that have been considered [10, 12, 23, 25-28]. These measurable methodologies additionally aid the recognizable proof of expected factors and sources that affect water frameworks. Moreover, they give a crucial instrument to the reliable administration of water assets and the quick goal of contamination issues [10, 11, 23, 25, 29, 30].

Regular cycles (changes in precipitation, disintegration, and enduring of crustal materials) and anthropogenic impacts (agrarian practices, expanded abuse of water asset, sewage spillover, horticulture, and never-ending suburbia) have been refered to as the reasons for the far reaching crumbling in water quality that has been seen in Wular lake throughout the span of the beyond couple of many years [36, 37]. Wular Lake has been encountering a serious crumbling of water quality as an outcome of the rising creation and release of toxins that are the consequence of human exercises. This adversely affects the capacity of neighborhood economies to work in a maintainable way. Furthermore, the eutrophication of Wular Lake has been achieved as an outcome of the expanded conveyance of supplements that have been achieved by both normal and human cycles [38, 39]. Considering the contamination gives that have been examined before as to Lake Wular, the ebb and flow examination was completed fully intent on distinguishing the wellsprings of contamination and the variables that add to the different spatiotemporal varieties in water quality.

II. MATERIALS AND METHODOLOGY

A. Study Area

The Kashmir valley is a lacustrine bowl that is important for the intermontane sadness that was made between the lesser and the more prominent Himalaya. It is situated on the northern edge of the Indian subcontinent. There is an incredible assortment of freshwater bodies, streams, lakes, lakes, and waterways that are notable all around the globe for their magnificence and the normal scene that they give. Not in the least do these immense and different freshwater territories assume an essential part in the protection of hereditary assets of the two plants and creatures, however they likewise have a lot of stylish, social, social, and land significance. The catchment districts of these lakes have seen a critical flood of supplements as an outcome of the exercises that have been brought about by human development [40, 41]. The maturing system of these lakes is advanced as an outcome of these human elements, which make the water quality corrupt as well as affect the oceanic species that lives in the lakes [42-44]. Countless the lakes in the Kashmir valley are showing indications of eutrophication as an immediate consequence of this [45-47].

Geologically talking, the Wular Lake, which is viewed as one of the biggest wetland regions in Asia, is situated at a height of 1,580 meters above mean ocean level. It is arranged between the scopes of 34 degrees 16 minutes north and 34 degrees 20 minutes north and the longitudes of 74 degrees 33 minutes east and 74 degrees 44 minutes east (Figure 1). The wandering of the Waterway Jhelum, which is the essential taking care of course notwithstanding different feeders, is liable for the development of Wular Lake, which is a bull bow type lake. It is arranged in the north-west of Kashmir, around 35 kilometers from the city of Srinagar. Notwithstanding its capability as a huge maintenance bowl for floodwaters, it likewise has a significant impact in the hydrography of the Kashmir valley by guaranteeing that streams are kept up with in a way that is helpful for horticultural creation, the age of hydropower, and the cooperation in games. The lake, notwithstanding the enormous swamps that encompass it, fills in as a significant living space for fish, and it is answerable for a little over half of the fish creation that happens inside the territory of Jammu and Kashmir [36]. There is a most extreme profundity of 5.8 meters in the lake, with the more deeply part of the lake being situated on the western side, inverse the slopes of Baba Shakur Noise. The lake is generally shallow. The sole outpouring for the lake is the Waterway Jhelum, which is situated in the northeastern piece of the lake. Table 1 gives an outline of the principal qualities of the exploration destinations. Erin and Madhumati are two of the most outstanding nallahs in the catchment region of the lake, which is made of slanted slopes of the Zanskar piles of the western Himalaya on the northeastern and northwestern sides. These slopes channel their overflow through an assortment of nallahs. Up until an enormous number of confusing dikes were worked along the Stream Jhelum, the lowlying segments of Sonawari, which are situated on the eastern and southern banks, were inclined to flooding for all intents and purposes consistently. In the new past, the lake region that was recuperated thusly has been put to use for the creation of paddy as well as plantings of willow, poplar, and natural product trees. In the Sopore-Watlab area, which is situated on the western side, low-lying locales have additionally been brought under paddy development. Under the Wetlands Program of the Indian Government, the lake was proclaimed as a wetland of public interest in the year 1986. In the year 1990, it was enlisted as a wetland of global significance as per the Ramsar Show of 1975. Morphometric qualities of Wular Lake disregarding this, there has not been a finished examination led to date on the assessment of the spatiotemporal hydrochemistry of the lake.

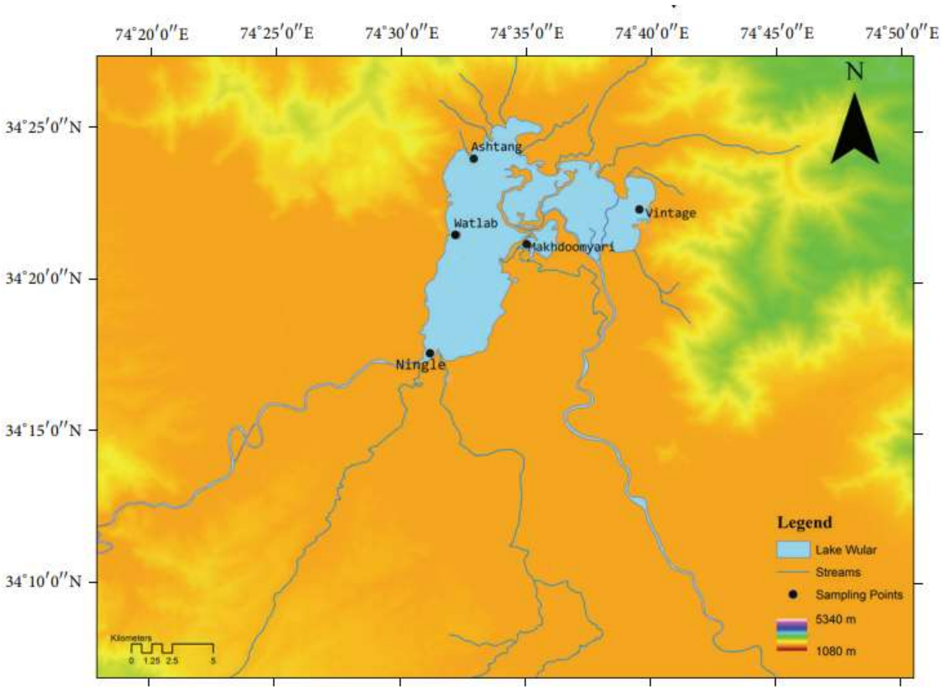


Figure 1: Showing layout of study area and surface water quality monitoring stations in Lake Wular.

B. Sampling and Analysis

Between February 2011 and January 2013, surface water tests going from 0.5 to 1.0 meters inside and out were gathered consistently from five unique areas. At each inspecting area, three delegate tests were gotten on every one of the examining dates. Inside a range of 24 hours, the water tests were put away in polypropylene one-liter containers that had been corrosive cleaned and put away at a temperature of four degrees Celsius in complete murkiness. To stop all microbiological movement in the water tests, an answer of soaked mercuric chloride was utilized at a last grouping of 0.2 milliliters per liter. A couple of the qualities, like profundity, straightforwardness, temperature, pH, and conductivity, were estimated right now, while different boundaries were estimated in the research facility. Inside 24 hours of the testing, the boundaries that were estimated in the research center were as per the following: orthophosphorus, absolute phosphorus, ammoniacal nitrogen, nitrite nitrogen, nitrate nitrogen, natural nitrogen (Kjeldahl nitrogen short ammoniacal nitrogen), alkalinity, free carbon dioxide, conductivity, chloride, complete hardness, calcium hardness, magnesium hardness, sodium, potassium, silicate, sulfate, iron, and all out disintegrated solids. Standard methodology created by Mackereth, Golterman and Clymo, and the American General Wellbeing Affiliation [42] were utilized in the review.

C. Statistical Analysis

The information for the physicochemical properties of the water tests were given as mean qualities, and graphic examination was utilized to inspect the information. To characterize the spatiotemporal level of variances of the noticed water quality measurements in Lake Wular, we utilized the standard deviation. This procedure was applied across various months and seasons. The whole perception time frame was separated into four fixed seasons before we started our examination concerning the occasional impact on water quality boundaries. These seasons were as per the following: spring (Walk, April, and May), summer (June, July, and August), harvest time (September, October, and November), and winter (December, January, and February).

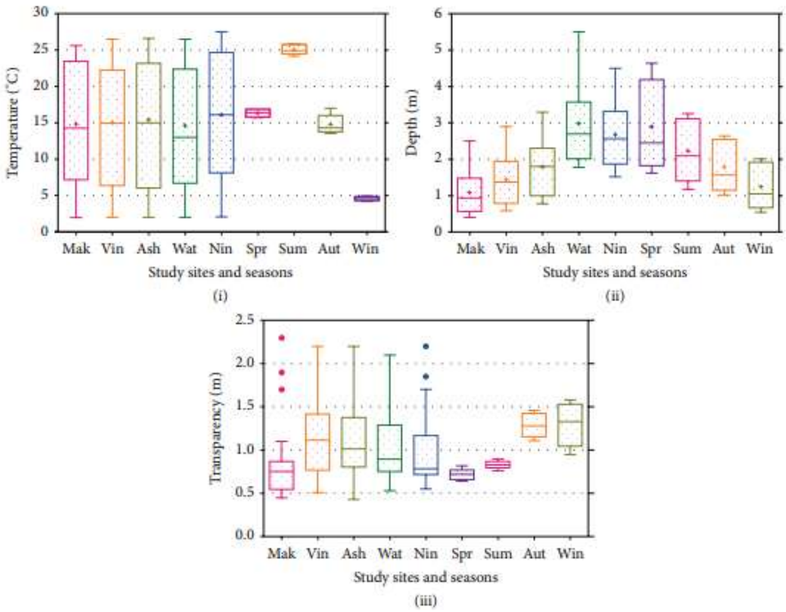
D. Water Quality Index

To form a decent open strategy and really executing the water quality improvement programs, fundamental to have data is both precise and exceptional on the nature of the water. With regards to really imparting data on the examples of water quality, files are among the best instruments. The Water Quality Record (WQI) is a numerical device that is utilized to work with the change of significant measures of water quality information into a solitary mathematical worth that sums up a few quality variables. The WQI is a list that actions the nature of water for a specific reason. It is a number juggling weighting of standardized water quality information that is the list according to a numerical viewpoint. There are varieties in the weightings concerning the different water utilizations [43, 44]. From an overall perspective, the records might be isolated into two classes: the physicochemical files and the organic lists. The upsides of various physicochemical boundaries in a water test are utilized to work out the physicochemical files, while the natural lists are gotten from the natural data and are figured by considering the species structure of the example, the variety of species, the dissemination example of the species, the presence or nonattendance of the pointer species or gatherings, etc [45]. Based on Harkins [46] and Lohani [47], a work has been made to build the water quality file of Wular Lake. This file was subsequently changed by Tiwari et al. [48] in view of physicochemical information gathered over a time of two years.

III. RESULTS AND DISCUSSION

A. Physicochemical Parameters

All through this examination, which went on for quite a long time, the way of behaving of the lake was explored by observing 27 qualities to assess the nature of this oceanic framework. In view of the information displayed in Figure 1, these not entirely set in stone by dissecting tests got from a few exploration stations situated inside the Wular Lake. In Figures 2(a), 2(b), 2(c), and 2(d), the mean, standard deviation, and scope of water quality measurements for every one of the five examination areas are shown (d). Throughout a two-year research that was directed at Wular Lake, box and stubble plots were utilized to show the entire spatiotemporal elements of physical, synthetic, nourishing, and ionic variables. Demonstrating the presence of worldly and geological vacillations, the huge standard deviation of most of values proposes that these varieties are doubtlessly created by contaminating sources and additionally climatic factors [25]. Throughout the cold weather months, the mean water temperature was at a low of 4.2 degrees Celsius, while throughout the late spring months, it arrived at a high of 25.6 degrees Celsius. The temperature of the water is an impression of the temperature of the environment, and the trademark most essentially fluctuates from one season to another. Throughout the span of the year, the typical straightforwardness shifted from 0.86 to 1.15 meters or more. Those areas that were nearer to the inflows had a lesser profundity than those that were nearer to the surges. It has been resolved that the showing up residue from the catchment is answerable for the unfortunate straightforwardness esteem that might be found in some water bodies situated in the Himalayan locale of Kashmir at high elevations [23]. Across all example areas, the most extreme worth of water lucidity was seen throughout the cold weather months. This peculiarity might be credited to the presence of low degrees of suspended natural matter related to unfortunate degrees of planktonic improvement [24]. It was basically at site I (154.11 ± 32.2), which is arranged in nearness to the lake's key inflow, that the best typical all out broke down solids (TDS) level was estimated. The complete disintegrated solids (TDS) was additionally found to show occasional change, with lower levels during the dry season (harvest time) and more prominent qualities during the wet season (spring). Contrasts in DO are expected to happen because of the temperature differential. The dissolvability of oxygen in water reduces with climbing temperature, which is the justification for why broken down oxygen has a negative relationship with temperature [25]. This is that was expected. The area that was put in closeness to an enormous stream was found to have the most noteworthy typical pH, which was estimated at 7.84 ± 0.34. An extensive fleeting vacillation was seen in the mean pH of the water body, which went from 7.2 to 8.5 percent. At the point when the pH was estimated in this examination, it was viewed as in the basic reach, which demonstrates that the lakes were satisfactorily cradled during the term of the review. The useful person of a waterway is shown by a pH range that falls between 7.2 to 8.5 [26]. The EC changed somewhere in the range of 100 and 387 $\boldsymbol{\theta}$S cm−1 throughout the year. When contrasted with the fall and winter seasons, the EC was a lot of lower throughout the spring and summer seasons. [28] The take-up of supplements via autotrophs was the reason for the spring-mid year time frames. As a result of the huge measure of human exercises, for example, waste disposal and horticultural overflow, the lake had a more noteworthy worth of electrical conductivity (EC), which is an impression of them. The conveyance of broken up oxygen (DO) across various example seasons displayed a huge transient vacillation, with the worth being lower in the late spring by 7.8 ± 0.19 mg L−1 and higher by 10.1 ± 0.16 mg L−1 throughout the colder time of year season. A characteristic system is liable for the opposite association among temperature and disintegrated oxygen. This is because of the way that hotter water gets all the more immediately immersed with oxygen, and it additionally can contain less broke down oxygen [23]. Locales III and IV revealed the best degrees of free carbon dioxide throughout the cold weather months, while site VI recorded the most significant levels throughout the spring months. Throughout the mid year season, a decline in CO2 levels is demonstrative of the utilization of CO2 because of high paces of photosynthesis via autotrophs, which thus brings about a decrease in pH [30]. At every single example area, a particular occasional example was found in the hardness. The alkalinity showed varieties across stations, with the most noteworthy typical vales (10.04 ± 3.17 and 10.43 ± 3.31 mg L−1) being recorded at destinations IV and V individually separately.



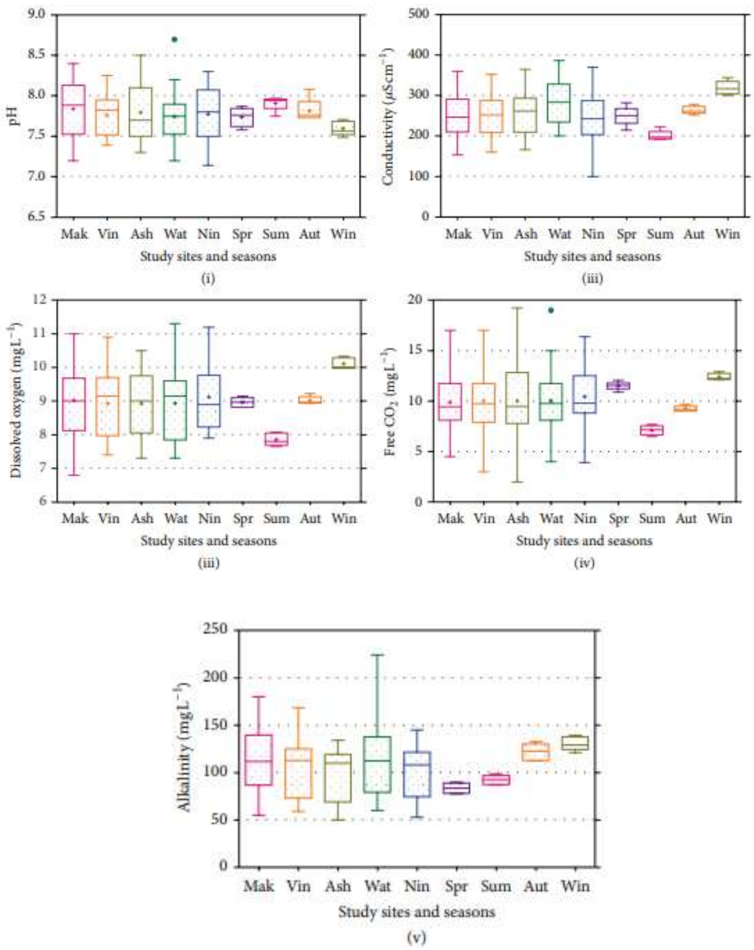


Figure 2: (a) Box and whisker plots showing spatiotemporal dynamics of physical parameters. (b) Box and whisker plots showing spatiotemporal dynamics of chemical parameters.

B. Water Quality Index

It's anything but a straightforward cycle to assess the general nature of the water, particularly when different models are utilized for various utilizations of the water. Likewise, the order of water quality sticks to different guidelines concerning the data included inside the different water quality boundaries. Countless factors have been created and are as of now accessible for use in administration programs that are either legislative or ecological in nature. In any case, the significant expense of water examination that is expected to partake in these projects makes it by and large hard to utilize these factors. The utilization of the water quality file procedure to Lake Wular in this examination has the motivation behind offering a clear and solid system for communicating the results of various models to give a more catalyst and simple assessment of the water quality. Because of joining a ton of different variables into a solitary number, the file might be effectively deciphered, which makes it a helpful device for the executives reasons. Utilizing thirteen rules, the Water Quality List (WQI) may give a sign of the wellbeing of the water body at better places. It can likewise be utilized to screen and assess changes over the long haul. Be that as it may, elective arrangements can be utilized in a more practical way.

As per Table 5, the upsides of water quality records are viewed as the measures for drinking water. As per the discoveries of the water quality record, which utilized thirteen measures, the qualities for locales I, II, III, IV, and V were as per the following: 49.2, 46.5, 47.3, 40.6, and 37.1, separately. There are five particular kinds of water that correspond to the WQI, and every one has its own exceptional status. It ought to shock no one that the surface water tests taken from the lake being scrutinized are of a good quality. Notwithstanding, on account of stations that are arranged in closeness to lake feeders, the nature of the examples that are assembled from the lake is raised. Here is the capability 1 15 10 5 0 −5 −10 −15. The capability 2 is addressed by the situation −15 −10 −5 0 5 10 15 4 3 2 1 Gathering centroid 4, Pre-winter 3, Summer 2, Spring 1, Winter Seasons A discriminant plot delineating the transient difference in water boundaries saw in Lake Wular is displayed in Figure 4. (2012-2013). flagging weighty contamination. The presence of a high amount of iron and a few different qualities is the essential driver of the great WQI that is found in these occurrences. The water quality file (WQI) assessment uncovered that the lake's water is in a good state for utilization, however the raised readings act as an advance notice concerning expected future ramifications.

Furthermore, calcium was the dominating component in Wular Lake, trailed by magnesium. It is conceivable that the accessibility of calcium and magnesium particles was brought about by a mix of variables, including the synthetic denudation that happened because of weakening brought about by weighty downpours, the course of the supply, and enduring brought about by rock and overflows from watersheds in the encompassing region. The presence of a thick populace of microscopic fish, especially Cyanophyceae, has been connected to the presence of high centralizations of calcium and magnesium in the freshwater collections of the Kashmir Himalaya [42]. Due to the presence of calcium and magnesium particles at moderate sums, the supply is delegated eutrophic, and that implies that supporting a wide assortment of plant and creature life, including fish will be capable. By and large, streams that have calcium levels under 10 mg L^{-1} are accepted to be oligotrophic, while waters with calcium levels past 25 mg L^{-1} are viewed as eutrophic.

IV. CONCLUSION

With the end goal of this examination, factual and numerical exploratory techniques were applied to survey the assortment of surface water quality contrasts that were seen in Lake Wular. Both occasional factors and anthropogenic elements have been shown to be the main supporters of varieties in water quality, as per the discoveries of this examination. The discoveries show that the DA approach is viable in the flow ensured classification of surface waters over the entire lake bowl. As a result, the quantity of test destinations and the expenses related with them might be diminished later on checking plans. A numerical articulation was provided by the water quality file, which was utilized to change over an enormous number of factors' information into a solitary worth that demonstrated the water quality level of the entire Wular Lake bowl. Subsequently, the review exhibits the helpful utilization of chemometric methods for the examination and translation of lake water quality information, as well as distinguishing proof in view of the situation with contamination and the ID of wellsprings of contamination, as a feature of the endeavors to deal with the lake while guaranteeing its maintainability. It was resolved that home wastewater, farming exercises, and overflow were the essential drivers of contamination; notwithstanding, the degree to which these sources added to each station's tainting levels fluctuated. These discoveries give fundamental data that might be utilized during the time spent laying out additional compelling answers for the administration of water contamination in the Wular Lake.

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