



ROLE OF REMOTE SENSING IN DETERMINING THE QUALITY OF GROUND WATER

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ABSTRACT

The importance of geographic information systems (GIS) and remote sensing in water resource management has been recognized for some time. Nevertheless, the main focus of this study is on the use of remote sensing and geographic information systems (GIS) to the monitoring of specific indicators of water quality, such as turbidity, dissolved organic matter, and suspended matter. In point of fact, the capabilities of this technology give helpful tools that may be utilized in the process of putting water quality monitoring and management into practice all around the country. The concept of sustainable water resource management is one that may be implemented and administered in the next years. The application of computer modeling, remote sensing, and geographic information system (GIS) technologies might be of considerable assistance to the government in the process of formulating regulations pertaining to the quality of the water supply.

Keywords: Remote sensing-GIS, Water quality, Monitoring, Water sustainability

INTRODUCTION

Both the continuous survival of people and the general health of ecosystems are dependent on the availability of water, which is a valuable natural resource. Water is essential for both. Two distinct types of bodies of water may be differentiated from one another: coastal water bodies and inland water bodies (lakes, river and groundwater). An rise in anthropogenic activity, particularly in industrial regions, has had an impact on water bodies during the past several decades. These effects may be seen mainly in surface waters. These impacts have been more obvious over the course of the past several years. These are global crises that are taking place in different parts of the world right now, and Malaysia is not exempt from the repercussions of these challenges. The development of science and technology in recent decades has contributed to an increase in population, industry, agricultural activities, and urban growth along the corridors or riverbanks of Malaysia. These corridors or riverbanks are generally located in more economically developed parts of the country. It's possible that the effluents from factories, the sewage from households, and the waste from fields are all contributing factors to the rivers' increasingly unappealing water quality. As a consequence of this, the river water quality monitoring program is necessary in order to handle the ramifications of both present problems regarding pollution to water resources and future worries regarding the same. In order to bring about constructive change and raise the level of public awareness at the same time, this is important. There are three separate categories that may be used to classify the qualities that water possesses; these are the physical, the biological, and the chemical qualities. These characteristics are taken into account by the software that is used to monitor the water. The Department of Environment Malaysia carried out a monitoring program in order to evaluate

the general quality of the water over the entirety of Malaysia (DOE). In the year 2006, there were a total of 1064 monitoring stations spread out throughout 143 distinct river basins, as stated in the report. Six hundred thirty-eight of them were assessed as clean, which represents sixty percent; three hundred seventy-six were rated as such, which represents thirty-five percent; and fifty were rated as such, which represents five percent. It is feasible to collect these crucial pieces of information, which can then be utilized to provide a basis for comparing the stream in the state throughout different times of the year and seasons. The monitoring and assessment that is now being carried out ought to be beneficial to the research as well as the creation of policies. At this point in time, the procedures that are applied to evaluate the quality of the water include measurements taken in-situ as well as the collection of water samples for the purpose of conducting future testing in labs. These measurements are accurate at a particular instant in time and location, but they do not offer an accurate picture of the water quality across a vast area, either spatially or temporally. As a result of this, technological advancements like remote sensing and geographic information systems (GIS) are particularly useful as instruments for evaluating and keeping an eye on the quality of the water.

The Present State of Affairs Regarding the Quality of the Water Supply Available Across the Whole Nation of Malaysia

Logging and the development of land for industrial and natural-resources activity were found to be the two primary contributors to river pollution in Malaysia. The former entails the opening of additional agricultural land, while the latter contributes to the destruction of trees. Both of these initiatives will result in additional land being made available for agricultural use. Prior to these operations, all of these concerns—the sedimentation in rivers, the mixing of particles, the turbidity, and the presence of organic chemicals in water—already existed. The most current collection of information on the quality of river water and ground water was carried out in the year 2007 by the Department of Environment Malaysia (DOE), which is Malaysia's environmental protection agency. This particular data collection was conducted out in the year 2007. From 1978, the show's transmission has been uninterrupted throughout its entire history. We looked at a variety of different metrics as possible indicators of the water's quality. Some of these metrics include dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), ammoniac nitrogen (NH₃-N), suspended solids (SS), and pH.

The three different regions of Malaysia, Peninsular Malaysia, Sabah, and Sarawak, have a combined total of 1064 monitoring stations to evaluate the quality of their individual water sources. There are 143 distinct river basins on every continent that are home to one of these stations (Figure 1 and 2). Six hundred thirty-eight, which is sixty percent, are seen as being clean, three hundred seventy-six, which is thirty-five percent, are viewed as being just moderately contaminated, and fifty, which is five percent, are regarded as being extremely polluted. It is commonly discovered that the water quality that is being monitored at upstream monitoring stations is of a higher level than that which is being monitored at downstream monitoring stations. The most significant levels of three different kinds of pollutants were found: dissolved solids (TSS), biochemical oxygen demand (BOD), and ammonia nitrogen (NH₃-N) (SS). Sungai Pinang, Sungai Juru, Sungai Merlimau, Sungai Danga, Sungai Segget, Kawasan Pasir Gudang, and Sungai Tebrau are a smattering of the polluted rivers (red color) in Peninsular Malaysia's development and industrial regions (Figure 1). It is imperative that the government, legislators, and the general public confront this issue and take steps toward conservation in order to prevent the quality of the water in rivers from

deteriorating, for the sake of future generations who will benefit from these actions. In addition to that, carrying out these actions is necessary in order to preserve the health of the surrounding environment.

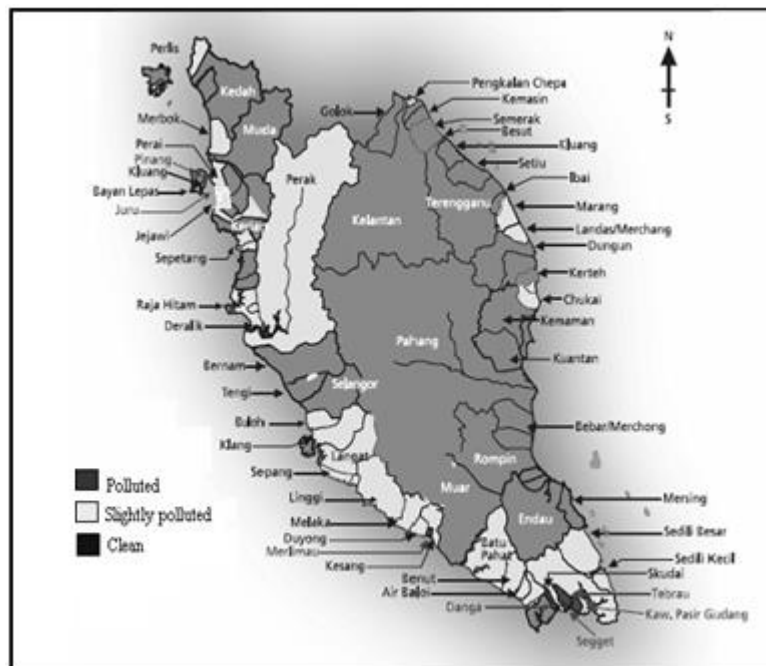


Figure 1. Peninsular Malaysia river basin water quality, 2007.

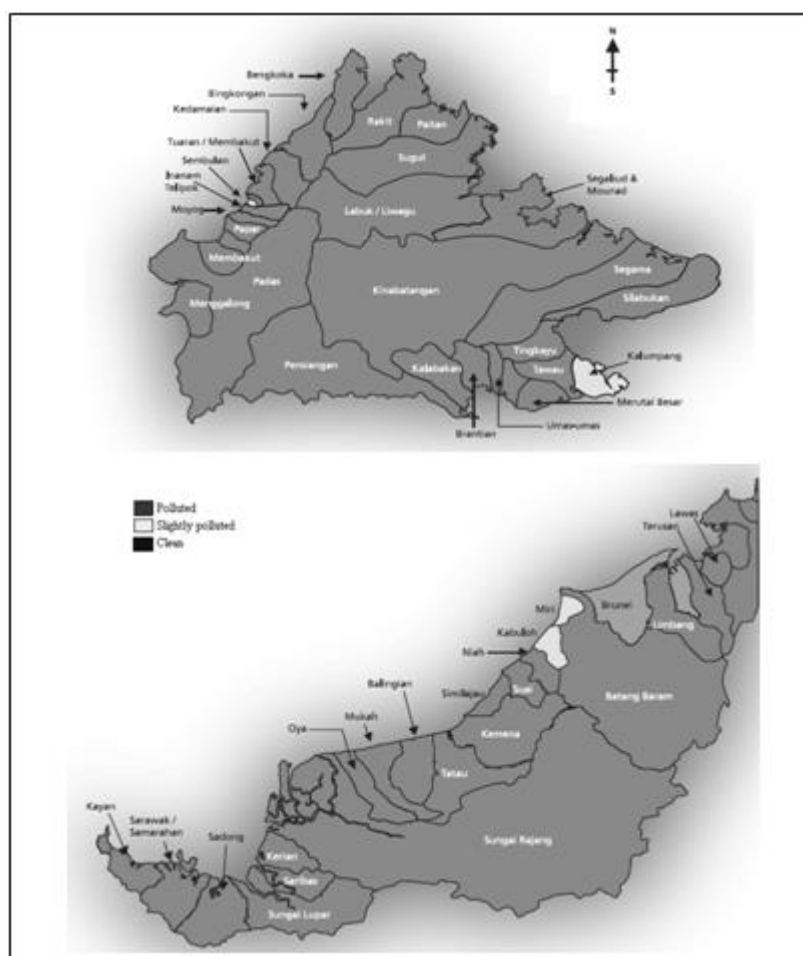


Figure 2. River basin water quality in Sabah (top) and Sarawak (bottom), 2007.

In the process of being carried out right now is an analysis of the water supply in Malaysia.

At the present moment, there is not a single organization in Malaysia that is in charge of the management of the whole water supply for the country as a whole. The circumstance now stands as described. Despite the fact that a large number of government entities in Malaysia are responsible for different aspects of water management, this continues to be the case. The Department of Irrigation and Drainage (DID) is in charge of a vast array of operations, some of which include hydrology, river management, flood mitigation, coastal management, and storm water management. Other responsibilities include storm water management and coastal management. Additional tasks include the management of coastal regions and the water from storms. In addition to that, it is the responsibility of DID to manage storm water. In addition, the Department of Public Works is responsible for the delivery of water to both private houses and business facilities in the city. This responsibility falls within the jurisdiction of the city. On the other hand, it is the obligation of the Department of Environment to reduce the overall amount of water pollution that occurs. This is one of the responsibilities that they have. Issues that are brought up by the management of water resources, such as the distribution of water rights, the management of floods, the control of pollution, and the preservation of the environment, are addressed through the utilization of inter-agency cooperation and consultation as a means of finding solutions to these problems. Other issues that are brought up by the management of water resources include the management of floods, the control of pollution, and the preservation of the environment. It is realistic to predict that state governments will play the primary role in the management of water resources. This is because the Constitution of the United States placed the ownership of water and the administration of water under the jurisdiction of the state governments. This is due to the fact that it is realistic to predict that state governments would play the primary role in the management of water resources. As a result of this, this situation has come about. Due to this provision, the authority to manage water resources is turned over to the governments of the several states. The National Water Services Commission, also known as SPAN (Suruhanjaya Perkhidmatan Air Negara), was established in 2006 by the government of Malaysia for the purposes of supervising and regulating water supply services and sewerage services, as well as for the purposes of enforcing laws pertaining to water supply and sewerage services. In addition, the National Water Services Commission was established for the purposes of enforcing laws pertaining to water supply and sewerage services. In addition, the National Water Services Commission was founded for the goal of enforcing laws that are related to water supply and sewerage services. This commission was created in order to meet the needs of the public. In addition, the National Water Services Commission was established with the intention of enforcing regulations that are associated with water supply and sewerage services. This was the commission's primary reason for being established. This commission was established so that it could better serve the requirements of the general public. After being adopted by the legislature the year before and then being signed into law in 2006, the SPAN Act of 2006 took effect on February 1, 2007, exactly one year after it was passed into law. In the meanwhile, the Ministry of Agriculture in Malaysia founded what is now known as the National Hydraulic Research Institute of Malaysia in September of 1995. It is generally referred to by its abbreviation, NAHRIM, which stands for National Hydraulic Research Institute of Malaysia. Even though it had previously been in charge of the organization, the Ministry of Natural Resources and the Environment was able to reclaim control of NAHRIM in the year 2000. This was the second time that this has occurred. Investigating river, coastal, geohydrological, and water-quality resources from both a

theoretical and practical vantage point was the mission of the organization. In addition to this, they act as a resource for both public and private enterprises, giving consulting services to these establishments on matters concerning water and the environment. They participate in this pastime rather frequently.

In-situ measurement is just one of the many methods that may be used to keep an eye on water quality and produce a WQI. Other methods include laboratory testing and visual inspection. Testing in a laboratory and taking samples are also two more techniques. The utilization of a diverse array of strategies is required to successfully complete this task. Conventional techniques of monitoring water quality indicators are not the only ones that may be utilized; if necessary, data from geographic information systems (GIS) and remote sensing can also be used in conjunction with the traditional approaches. In order to obtain the most accurate data possible for evaluating the many facets of water quality, personal observation and measurement are essential. The program that is intended to monitor the metrics that are used as an indication of water quality has established a number of goals for itself, which are stated in the following list. These objectives include the following:

- (i) I Am Working To Restore And Improve The Water Quality Of The River Such That It May Once Again Be Considered To Be In Its Original Pristine State.
- (ii) The water quality of Class III must be upgraded to meet or exceed Class II criteria in order for aquatic life to be able to thrive in it. Class III water typically has a WQI ranging from 51.68 to 75.37 and necessitates incentive water treatment prior to distribution (WQI 75.37 to 91.76, need water treatment for water supply and suitable for recreation)
- (iii) When the work on the project is accomplished, the water quality should be at least Class II, and it should be kept at that level by preservation, maintenance, and continued support.
- (iv) To encourage and foster the development of strategic partnerships between the public and private sectors in initiatives aimed at reducing pollution and revitalizing rivers.

Keeping a Close and Continuous Watch on the Condition of the Available Water Supply Utilizing Satellites

The process of determining the chemical, physical, and biological characteristics of bodies of water as well as the source of any pollution or contamination that might result in a reduction in the water's quality is referred to as a "water quality assessment." This process is referred to by the term "water quality assessment." During this step of the procedure, it is also necessary to locate the source of any pollution or contamination that may be contributing to a decline in the water's quality. These indicators of the quality of the water might be placed into one of the following groups, depending on the context in which they are considered: The following is a list of some categories that may be used to explain the various aspects that go into determining the quality of water: i refers to the biological aspect, which includes bacteria and algae; ii refers to the physical aspect, which includes temperature, turbidity and clarity, color, salinity, suspended solids, and dissolved solids; iii refers to the chemical aspect, which includes pH, dissolved oxygen, biological oxygen demand, nutrients (including nitrogen and phosphorus); organic and inorganic compounds (including toxicants); and iv refers to the aesthetic aspect, which includes the appearance of the water. I am biological, a category that includes algae and microorganisms. ii. The physical

characteristics, which include the temperature, turbidity and purity of the water, color, and salinity (odors, taints, color, and floating matter).

Many research have been conducted, all of which have conclusively demonstrated the usefulness of utilizing remote sensing in order to keep an eye on the quality of the water. According to the findings of these research, using remote sensing to keep an eye on water quality is an effective way to monitor it (Ritchie and Charles, 1996; Dekker et al., 2002 and Schalles et al., 1998). The term "remote sensing" refers to the act of acquiring and evaluating data collected from a distance, as opposed to directly from the object, place, or phenomena of interest itself. This can be accomplished by sending sensors to a location some distance away from the target of interest. Many different kinds of technological advancements are able to bring about this result. This particular method is referred to as "remote sensing," which is the word that is used to describe it (Thomas et al., 2004). In the 1970s, a pioneering effort to monitor the water's quality utilizing remote sensing technology was launched. The goal of this endeavor was to improve water safety. Attempting this was a move in the appropriate course of action. The following is an example of a generic equation that was developed by Ritchie and his colleagues in 1974 as an early empirical approach for determining the quantity of sediments that are suspended in water. The equation can be thought of as an example of a generic equation because it was established in 1974. It is possible to apply this equation to arrive at an estimate for the total volume of sediments that are suspended.

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$$Y=A+BX \text{ or } Y=AB^X$$

When Y is the reading of radiance, reflectance, or energy from a remote sensing sensor and X is any indicator of water quality that is of interest to the researcher. Y and X are separated by an equal sign. The reading is the letter Y. (i.e., suspended sediment, turbidity). The values of empirical parameters A and B were determined by applying a statistical relationship between spectral reflectance and in-situ measurements of water quality. This link enabled the researchers to determine the values of the empirical parameters. It is generally agreed that both A and B are examples of empirical parameters. It was revealed that the values of A and B are identical to one another in every way. It is possible to utilize the spectrum reflectance to shed light on which wavelength(s) or frequency(es) are most effective for addressing a certain component of water quality. This equation has been utilized by a number of academics coming from a wide range of academic disciplines in order to draw a variety of conclusions on the characteristics of the water. After an empirical equation has been constructed for a particular water quality measure, it will be possible to use that equation in the future to estimate the value of that metric for the region that is the primary focus of the investigation that is currently being carried out. This investigation is being carried out by the government in order to determine whether or not there is a problem with the water quality in the region.

Materials That Are Currently Held in the State of Suspension

In the suspension, there is a mixture of organic and inorganic components, and these two types of compounds are discovered to coexist. Both of these categories of chemicals have yet to be uncovered in their entirety. When it comes to the regulation of water quality, the connection between suspended matter and total primary production, as well as fluxes of heavy metals and micropollutants, is an extremely

important factor to keep in mind. This is because suspended matter is a very significant component. The reason for this is given in the previous sentence. The great majority of pollutants that may be found in surface waters are found in the form of debris that is suspended in those waterways. The link that exists between the silt that is suspended in water and the reflectance of the water has been investigated by a number of academic scholars throughout the years. Electromagnetic radiation in the visible and near-infrared parts of the spectrum is increased in the presence of sediments that are suspended in the surface water. The reason for this is the contact that the water has with the sediments (Ritchie and Charles, 1996). In-situ and laboratory tests have shown that the brightness of the water's surface may be affected by a variety of factors, some of which include the type of sediment, the texture of the sediment, the color of the sediment, the view from the sensor, the angle at which the sun is shining, and the depth of the water. Other factors that may have an effect on the brightness of the water's surface include the color of the sediment, the view from the sensor, and the angle at which the sun is shining. The color of the sediment is another characteristic that, among other things, may influence how reflective the water's surface seems to be (Ritchie and Frank, 1998).

It is feasible to compute and map the concentrations of suspended materials that are present in inland waterways by making use of remote sensing technologies, which give useful geographical and temporal context. These technologies may be used to gather information. This configuration has the potential to either have a short-term or a long-term outcome. Studies of suspended materials using remote sensing have made use of a broad range of satellite platforms, including as Landsat, SPOT, IRS, the Coastal Zone Color Scanner (CZCS), and the Sea-viewing Wide Field of View Sensor. These platforms have been utilized in a number of different ways. Coastal Zone Color Scanner is the abbreviation for this NASA instrument, which was designed by NASA (SeaWiFS). According to the findings of these experiments, there is a significant relationship between the presence of suspended materials and the brightness or reflectance of a single band or a combination of bands as observed from satellite or aerial platforms. This relationship was found to exist regardless of whether the bands were observed individually or in combination. This association was discovered to exist regardless of whether the bands were examined alone or together throughout the course of the research. In-situ research revealed that the most effective range of wavelengths for recognizing suspended particles in open water is between 700 and 800 nm. This range was shown to be the most effective range of wavelengths. On the basis of the results of the investigation, we came to this conclusion (Ritchie et al., 1976). The amount of radiation that is absorbed by suspended sediment is an incredibly minute proportion of the amount that is dispersed by this material, which is a significantly bigger amount. This is in comparison to the amount of radiation that is absorbed by chlorophyll. When compared to remote sensing of aquatic bodies, which is restricted to a relatively narrow range of optical wavelength, remote sensing of terrestrial settings offers a much wider range of applications and can be put to a greater variety of different uses. This is because remote sensing of terrestrial settings provides information on a much larger scale. Because of this, the wavelengths that fall within the range of 400 to 850 nm are the ones that are capable of being used to identify the quality of the water with the greatest degree of accuracy. It has been demonstrated that TM4, which is an image that was obtained by Landsat, coincides quite well with TSM. As a result, researchers from a number of different studies have come to the conclusion that it is possible that it may be utilized for this purpose (Dekker et al., 2002). Phytoplankton

Eutrophication may be measured in a number of ways, one of which is by looking at the quantity of

chlorophyll that is contained within the cells of the algae that make up plankton. Algae are the primary component of plankton. The chemical reaction known as photosynthesis results in the production of a pigment known as chlorophyll. It is this pigment that is responsible for giving water its distinctive emerald hue. When determining the overall quality of the water, one of the most essential aspects to look at is the amount of chlorophyll a that is present. A significant amount of research has been conducted into the use of remote sensing to the mapping of this indicator of algal concentration (Schalles et al., 1998). Nevertheless, because to the independent changes in colored dissolved organic matter and particles, the methodical extraction of chlorophyll a from ocean color data in the vicinity of land has become increasingly challenging. Chlorophyll a has a greater dynamic range, and as a result, it transmits a more strong signal in inland waters. This is because inland waters are more stable (lakes, rivers, reservoirs).

While conducting an examination into the quality of the water, it is beneficial to utilize data on the number of phytoplankton as a means of estimating primary production and the carbon cycle. It is very difficult to obtain accurate measures of chlorophyll concentrations when there are cyanobacterial blooms in the area. The production of quantitative maps of cyanobacteria has been attempted with a certain degree of success thanks to the utilization of airborne remote sensing. This endeavor's objective was to gain a deeper comprehension of the patterns of dissemination of these microorganisms (Dekker, 1993). Ha'kanson and Moberg have employed multispectral sensors such as CZCS and SeaWiFS (Siegel and Gerth, 2000) and synthetic aperture radars (Svejkovsky and Shandley, 2001) to monitor the extent of cyanobacterial blooms in addition to broadband sensors such as AVHRR. This was done so that an accurate count of how extensive the blooms are could be obtained (1994). By applying remote sensing, one is not only able to determine the amount of chlorophyll present in a plant but also its distribution over the entirety of the plant. Anecdotal information about the association between narrow-band or band-ratio radiance and chlorophyll concentration is the primary source of data for the vast majority of the research that has been done on the chlorophyll content of water when viewed from space. This information has been used in the majority of the studies that have been conducted on the topic. The origin of these numbers may be traced back to anecdotal evidence about the connection between narrow-band or band-ratio radiance and chlorophyll content. Chlorophyll maps of the ocean, estuary, and fresh water have all been constructed by applying a broad range of techniques and wavelengths that have been gathered by aircraft, Landsat, SPOT, SeaWiFS, and CZCS data. These maps were all created by applying these techniques and wavelengths. The development of a wider variety of chlorophyll maps has been made possible as a result of this. In order for chlorophyll to be able to take in light, one school of thought suggests that the light in issue needs to have an extremely short wavelength. Several researchers believe that in the not-too-distant future, hyperspectral sensors will have to be deployed in order to keep track of the quantities of chlorophyll that are present in water. This is something that has been recommended to happen. Comparing the reflectance at 690 nm to the baseline, which spanned from 670 to 850 nm, provided the most precise assessment of chlorophyll concentration that could be achieved (Gitelson et al., 1995). The chlorophyll map of the Pensacola Bay Estuary in Florida that was built from data gathered by Landsat 7 ETM+ is presented for our perusal in Figure 3, which affords us the option to do so (Luoheng and Karen, 2005). Band rationing and regression, in particular the ratios of ETM+1/ETM+3, were applied in order to collect the most accurate estimations of chlorophyll a that it was feasible to obtain. This was accomplished by obtaining as much information as possible about the chlorophyll a concentration.

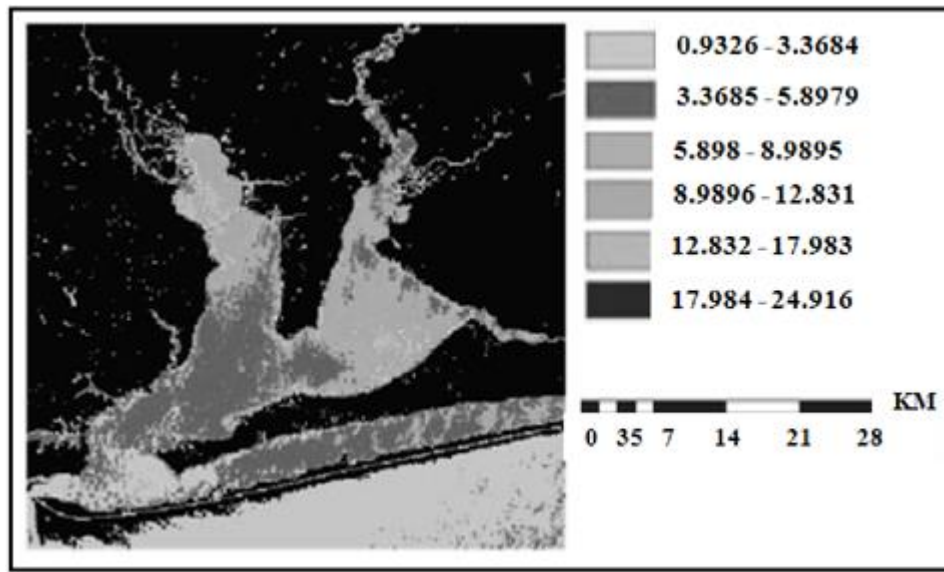


Figure 3. Chlorophyll *a* map of Pensacola Bay, Florida,USA

Turbidity

The turbidity of water is a sign of its optical properties, which cause it to scatter and absorb light rather than allowing light to travel through it unobstructed. These optical qualities give water its characteristic murkiness. These factors are responsible for the typical cloudy look of the water. The interaction of all of these components is what gives water its characteristic hazy appearance. As a direct result of this, it is typically seen as one of the factors that works against clarity. Historically, turbidity has been utilized as a proxy for suspended sediment concentrations in fluvial systems since suspended matter is the principal component that contributes to turbidity in water (Wass et al., 1997). It was found that the measurement of turbidity that was most accurate was red reflectance, which supported the findings of (Lathrop and Lillesand, 1986). It has been demonstrated through the use of satellite data with a high resolution that these types of data may be helpful for mapping the turbidity of the Lower Charles River in the United States. These findings were compiled by satellites like IKONOS, which were responsible for the data collection. The information that was obtained by these satellites can provide some clues as to why this is the case (Ferdin et al., 2007). It's possible that the IKONOS satellite, which, in contrast to other satellites, has a higher resolution, will be able to figure out how to fix this issue. You are welcome to examine the finalized version of the turbidity map, which can be seen in Figure 4.



Figure 4. Map of turbidity in the Lower Charles River in Boston,USA.

In addition to this, Liza (2007) investigated the turbidity of a lake in Alaska that was situated in close proximity to the Bering Glacier. In order to identify which factors are the most accurate predictors of turbidity in glacial lakes, a number of different Landsat 7 ETM-F bands were utilized in both basic and complicated linear regression analyses. This was done in an effort to find out which variables are the most important. When it came down to it, the most effective method for forecasting turbidity levels was to make use of data collected from the Landsat 7 ETM+ satellite's red and near-infrared areas of the electromagnetic spectrum. This information was obtained from space. The turbidity maps that are generated by the algorithm may be used throughout the duration of this inquiry in order to get more information on the yearly and seasonal fluctuations in the sedimentation rates of Vitus Lake. There is a possibility that academics will make use of this knowledge in order to enhance their capacity to foresee severe glacial occurrences such as floods and surges. If it is established that the Bering Glacier is discharging sediment-laden waters into Vitus Lake through subsurface conduits, then the turbidity maps may be able to shed some light on the glacier's hydrologic path and help shed some light on the glacier's hydrologic course. The implementation of the turbidity algorithm may be useful not just to other glacial lakes in south central Alaska, but also perhaps to glacial lakes located in other parts of the world. Brezonik (2005) conducted research on the mapping of turbidity and found that Landsat 5 TM Band 3 was the best accurate predictor of turbidity in a variety of lakes situated in the state of Minnesota. According to the findings of Wang et al. (2006), the most accurate methods for predicting turbidity in Reelfoot Lake, Tennessee, were to use Landsat 5 TM Band 2, Landsat 5 TM Band 3/Band 2, and a multivariate regression analysis employing Bands 3 and 2. These three methods were found to be the most effective. Chemicals that derive from organic sources Discovered in the Method

In addition to the labels water-coloring dissolved organic matter and gilvin, this material is also referred to by a wide number of other names. Yellow matter, aquatic humus, Gelbstoff, and colored dissolved organic matter are a few of the names that have been given to this substance. These expressions pertain to a group of organic compounds that have the potential to dissolve in water (and are consequently able to pass through a 0.45 m filter) while simultaneously having the capability to absorb a considerable amount of light of a certain wavelength. A group of organic compounds that may be discovered in nature and

range in color from yellow to brown are referred to as "colored dissolved organic matter" (CDOM). This word is abbreviated as "CDOM." These molecules are biogenic and diverse, and they are soluble in water (Aiken et al., 1985). Dissolved organic material that is capable of absorbing both ultraviolet (UV) and visible light is referred to as "CDOM," which is an acronym for the phrase. In addition, dissolved organic matter has an impact on the volume reflectance volume spectrum, but this influence is mostly observed at longer wavelengths (Bukata et al., 1985). CDOM has a high absorbance at wavelengths that are less than 500 nm, and its absorbance has been shown to rise exponentially as the wavelength decreases. [CDOM's] absorbance is highest at shorter wavelengths. Despite this, researchers have shown that high quantities of CDOM can cause red light to be absorbed, which can be seen under the right conditions (Strombeck, 2001). Since CDOM is so efficient at absorbing UV radiation, it shields phytoplankton and other forms of life from the sun's UVB rays, which can cause tissue damage if they are exposed for long enough. This is a significant benefit to consider (Green and Blough, 1995). Nevertheless, when CDOM concentrations rise, both the quantity and quality of the photosynthetically active sunlight that phytoplankton can receive drops. This has a negative impact on phytoplankton growth. This, in turn, has an effect on the structure of the ecosystem as well as the primary production that occurs inside it.

The formation of folic acids in situ, which is caused by the breakdown of seaweed, contributes to an increase in the concentration of CDOM seen in coastal waters. This is a result of both the primary production that is driven by nutrients (Del Castillo et al., 1999) and the anthropogenic input of industrial or residential effluents from inhabited regions. The primary production is stimulated by nutrients. Folic acid is formed as a byproduct of the decomposition of seaweed (Sieburth and Jensen 1969). (Bricaud et al., 1981). In coastal environments, the alteration of the optical characteristics of CDOM is somewhat influenced by both the presence of saltwater and the process of photodegradation.

In order to evaluate the standard of the water throughout the nation of Malaysia, the use of geospatial information systems and remote sensing technology has become widespread.

In Malaysia, the practice of monitoring the many characteristics that make up water quality through the application of remote sensing is just in its infancy at this point. The parameters of water quality in Malaysia are being monitored by means of a remote sensing technique for a variety of reasons. These reasons include the limitation of the field cost, the enhancement of the information contents, the production of a digital map, and the monitoring of water quality on a large scale, which will provide a significant source of data. In addition, remote sensing allows for the monitoring of water quality on a larger scale, which will provide a significant source of data. In general, the monitoring of water quality indicators in Malaysia is carried out in Malaysia through the use of a technology called remote sensing. A number of studies have been conducted in Malaysia, one of which was conducted on the island of Penang in 2001 by MatJafri and colleagues. This study utilized a satellite photo received from Malaysia's Tiungsat-1 in order to map the island's water quality. The satellite was located in Malaysia. In addition to these goals, the research wanted to determine the total quantity of particles that were suspended in the water and create a map depicting the quality of the water. Despite this, the best Tiungsat-1 picture that could be obtained for the area under study did not contain all of the data that was necessary to fully understand the suspended particles. They were able to do this by contrasting the sea-truth data obtained from the Landsat TM photographs with the data obtained from the equivalent Tiungsat-1 picture. Because of this, they were able to get around the issue. The picture that was shot on January 20, 2000 has the best level of connection with both the

Tiungsat-1 and Landsat TM photographs, as determined by the conclusions of the inquiry. The results of the in-situ measurements indicate that there is a positive correlation between DN and TSS, and the suitable values for R and Root Mean Squared (RMS) are 0.9256 and 3.6237 mg/l. This correlation is supported by the fact that there is a link between the two variables. Numerous research that used visible-channel remote sensing data to conduct examinations of suspended silt arrived to the same results and uncovered features that are comparable (Choubey, 1998).

Figure 5 shows that the highest concentrations of total suspended solids were found in the part of the channel that was located farthest south and in the portion of the channel that was located closest to the river mouths. The discharges coming from the rivers themselves were the source of the plumes that were located at the mouths of the rivers. There is a possibility that turbidity will rise to the surface of the water in an area of shallow water if the bottom of the region is stirred up by waves and winds. The deeper the depth of the water, the lower the perceived concentration gets. Using pictures from the Tiungsat-1 satellite, the results of the study were utilized to build a comprehensive map of the suspended water quality in the region surrounding Penang Island. They were unable to validate the apparent higher concentration on Penang Island's western side, however, since they did not have enough data on the sea's actual conditions.

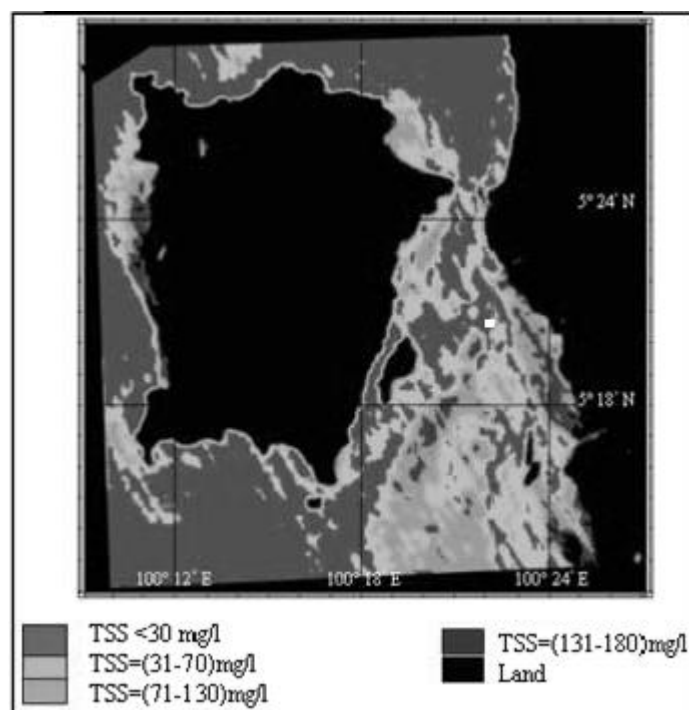


Figure 5. Total Suspended Solids (TSS) map of Penang Island, Malaysia

The groundwater potential zone in the Langat Basin was predicted with the use of integrated remote sensing and geographic information systems (Khairul et al., 2000). Since it is so far below the surface of the earth, ground water can only be located inferentially via the utilization of technologies such as remote sensing and geographic information system (GIS) technology. The purpose of the research was to determine groundwater potential zones through the application of remote sensing and thematic maps that were created using GIS. It was discovered that the bulk of the Langat basin is made up of alluvial plains, which is a kind of ecosystem that has a considerable potential for groundwater occurrence (Figure 6). In the map, the amount of groundwater output is represented by one of five different intensity levels (very

high, high, moderate, low, and very low). The DRASTIC model in GIS was developed in order to build a ground water potential zone based on one meteorological and seven biophysical features. This was accomplished by analyzing the data. In a landscape that is dominated by rugged mountains and granite with a sparse lineament density, the presence of groundwater is highly improbable. Yet, in places characterized by hard rock, locations with a high lineament density but a low drainage density offer a very considerable potential for groundwater. Satellite data have shown to be highly informative and useful when it comes to recognizing surface features and characteristics such as lineaments and land use.

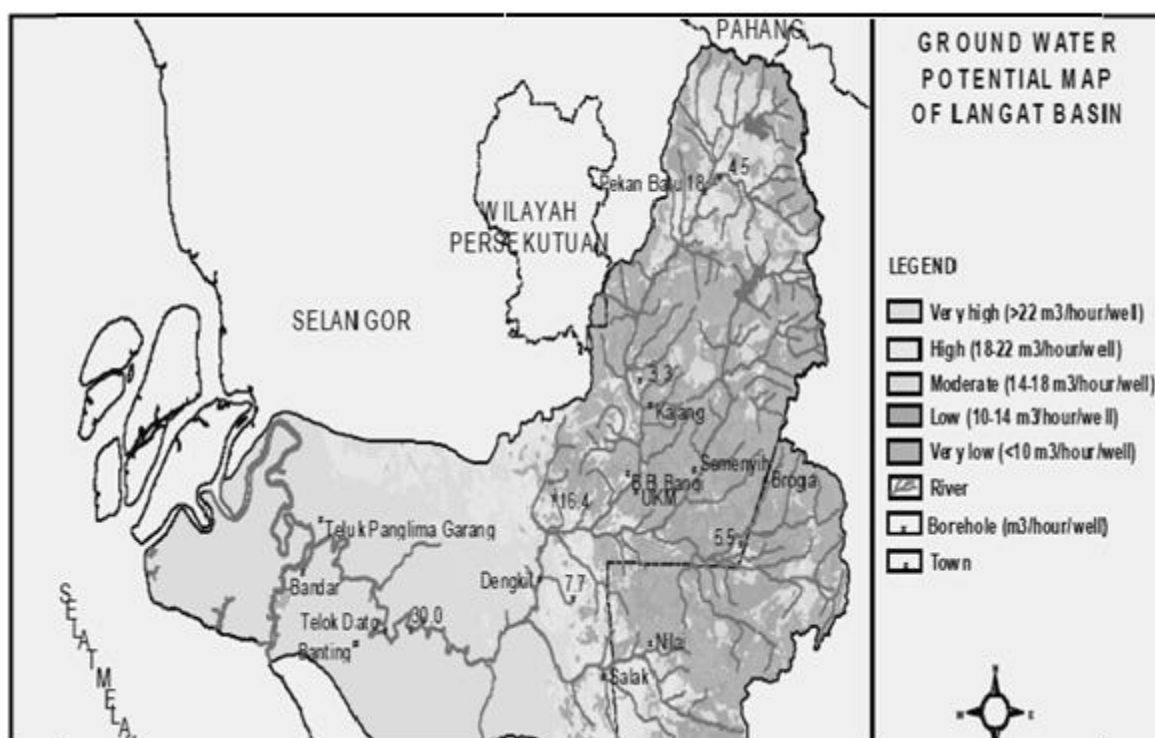


Figure 6. Groundwater potential map of the Langat Basin, Malaysia

An integrated study of thematic maps using a model that is based on GIS technologies is the strategy that has shown to be the most successful in groundwater potential forecast zoning. On the other hand, this research was only helpful for forecasting groundwater zones on terrain composed of hard rock, and it had a much smaller influence when applied in an alluvium environment. In the year 2000, the water quality of Langat and Semenyih Dam was mapped remotely using Landsat TM data, which allowed for remote monitoring. (Mohd Hasmadi and Kamaruzaman, 1999; Mohd Hasmadi and Kamaruzaman, 2000). The water that is stored in the Langat and Semenyih dams is essential to the survival of about 1.9 million people who live in Kuala Lumpur and the surrounding area. Based on the regression model between in-situ data and the spectral reflectance of the satellite photos, Figure 7 demonstrates that the turbidity values at Semenyih dam (left) and Langat dam (right) were, respectively, 5.0 NTU and 7.0 NTU. These results are shown in comparison to one another. The general population may rest easy knowing that these figures are still quite low and secure. The pace of sediment migration, on the other hand, poses a potential risk to the water quality of the dam in the future if preventative actions are not implemented. The turbidity distribution on the water's surface was analyzed by a separate group of researchers in Penang, Malaysia, who used an algorithm for their investigation (Sultan et al., 2004). The Total Suspended Solids reflectance model and the data from digital cameras were used in the development of the approach (TSS). It was

determined how successful various algorithmic approaches were. At long last, the optimal approach was selected, and a turbidity map was generated (Figure 8).



Figure 7. A maps of turbidity level of Semenyih (left) and Langat dam (right)

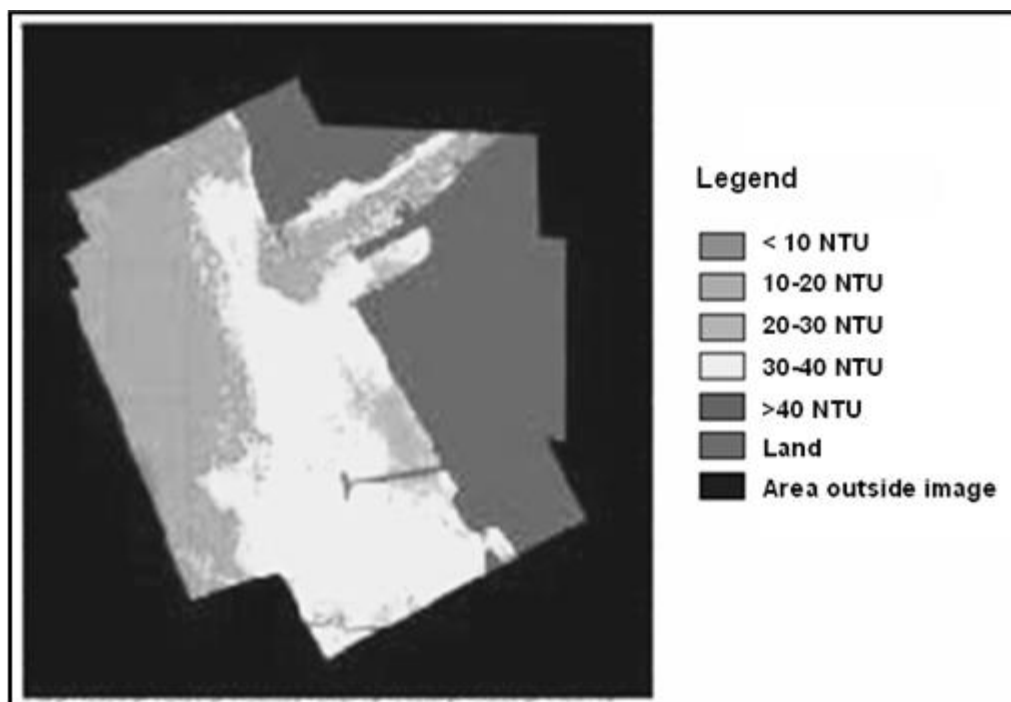


Figure 8. A map of turbidity near Prai River estuary, Penang

Advantages of Monitoring Water Quality Through the Use of Remote Sensing Technology

The ability of remote sensing observations to offer geographical and temporal information of surface water parameters is a key benefit of using remote sensing rather than conventional methods for monitoring water quality (Lindell et al., 1999). Satellites equipped with cutting-edge technology are able to continually monitor a broad variety of water quality measures, such as chlorophyll-a, suspended

sediment, yellow material, turbidity, Secchi disk depth, wave height, color index, and surface water temperature (Zhang et al., 2002). Investigations of the water quality in coastal and inland lakes have also made substantial use of remote sensing in recent years (Koponen et al., 2002). The use of remotely sensed data makes it possible to gain a long-term view on the area of interest that is nearly daily and to highlight seasonal and interannual fluctuations. These data also have the potential to provide insight on changes occurring on a regional basis. The use of remote sensing technology offers an alternative quantitative approach for monitoring water quality that is not only affordable but also repeatable. This opens the door to more efficient management of the water supply. In the past, remote sensing has been demonstrated helpful for a variety of purposes, including the monitoring of water quality by a number of different sources (Baban, 1993).

As contrast to limnological research, in-situ measurements are frequently done at fewer places. The use of remote sensing data, on the other hand, makes it possible to obtain a more comprehensive overview of the body of water, the ability to measure characteristics across a larger area as opposed to just a single point, the integration of multiple characteristics into a single composite measurement, and the refinement of models through constant or frequent feedback from satellite measurements. An active in situ sampling program makes it possible to validate remotely sensed goods and provide an evaluation of aspects that cannot be detected from space, such as shifting biota, substrate, and chemical composition. This is achieved by collecting samples of the target area in their natural environment. If we have a better understanding of these components and how they are related to remotely sensed products, we may be able to construct remotely sensed environmental indicators that will allow for improved environmental monitoring of aspects of the environment that cannot be seen directly from space.

CONCLUSION

There are a great number of establishments, including residences, that are dependent on water supplies. In addition, mines, livestock ranches, and agricultural fields all utilize water for irrigation purposes. Regrettably, the quality of the water is continuing to worsen as the rate of industrialization and the amount of human meddling in the natural environment continues to grow. As a result of this, in order to take effective action on any level, monitoring systems that incorporate remote sensing and GIS are required. When compared to the in-situ method, which restricts measurements to predetermined sample locations, remote sensing and geographic information system (GIS) techniques are more efficient, cost-effective, and advantageous instruments for monitoring water quality parameters in coastal level and fresh water bodies (lakes, river, ground water, and reservoir). High-resolution satellite images from platforms such as Landsat, SPOT, IKONOS, IRS, CZCS, hyper spectral, and SeaWiFS can be used to generate water quality parameter maps with the help of algorithms and models, according to previous research that made use of remote sensing and GIS methodologies. This is something that we know thanks to the findings of these studies. Because it can record up to 200 or more spectral channels at the same time, the recently developed method of hyperspectral imaging is a significantly more effective method of investigation. Since it captures images across such a broad spectrum of wavelengths all at once, hyperspectral imaging enables the collection of additional data concerning the quality of the water being examined. Reflectance that is measured between 400 and 850 nm can be utilized to estimate a variety of different water quality characteristics, including turbidity, dissolved organic matter, phytoplankton concentration, and suspended particles. These recent developments in the sustainable management of water resources hold

up the possibility of an expedient answer to issues relating to water quality in the not too distant future.

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