



Monitoring and maintaining groundwater quality: challenges and management

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Abstract

Water covers 70% of the world's total surface, but only around 3% of it is freshwater that humans may drink and utilize for other purposes. Because of fast growth in many nations, the quality of groundwater is no longer adequate for human consumption. The objective of the study is to assess the groundwater quality of 18 locations in the Ropar wetland in Punjab, India, in different seasons and different source groundwater. When compared to uncontaminated natural groundwater, the groundwater obtained from the test sites had higher pH values. The amount of groundwater pollution is higher in the summer than in the winter. However, there are many challenges face by the groundwater quality research. The groundwater quality in any region of the world is very important towards the survival of human being. Long-term consumption of polluted groundwater with high levels of heavy metals will result in health issues such as difficulty breathing and renal failure.

Keyword :

Groundwater, contaminated groundwater, groundwater management, groundwater in wetland

1 Introductions

Water is the most vital resource on earth which the survival of mankind will not be possible without the presence of water (Usha, 2011). Thus, there will be no living things on earth without the presence of water. Water have covered 70 percent of the world total surface but there are only less than 3 percent of the water are freshwater that are safe to consume by human and use for other human activities (Behailu, Badessa and Tewodros, 2017). Therefore, it is very common condition that there are many people on the world could not have proper access towards clean and consumable water as the demand for clean freshwater is always higher than that are able to supply (Sawyer et al., 2017). Groundwater is one of the most importance sources of freshwater that are used in human daily life, agricultural activity and industrial activity throughout the world (Kanmani and Gandhimathi, 2013). However, the rapid development in many countries have caused the quality of groundwater to be unsuitable for human consumption anymore (Liao et al., 2018). This is due to the contaminant from the industrial and agricultural sector that have leached or run off into the groundwater causing the groundwater to be polluted (Li, Feng et al., 2017).

In addition, the activity from mankind such as disposing rubbish into public areas or dumping waste without proper procedure have also caused the groundwater to be polluted (Kaur et al., 2019). The quality of the groundwater is very important towards mankind as the polluted groundwater will affects the health conditions of mankind and might cause the outbreak of disease (Ali et al., 2017). Long-term consuming of contaminated groundwater with high level of heavy metals will caused health problems such as difficulties in breathing, heart attack, kidney failure, neurological, hypertension and may even lead to death (Amadi et al., 2012).

The groundwater quality of 18 sites in Ropar wetland in Punjab, India have been analyzed to review the health risks that the locals are exposed to throughout the year. Ropar wetland is an industrial area which are surrounded by thermal power plant and cement factory (Jairath et al., 2008). The continuous growing of agricultural and residential project in Ropar wetlands have also greatly increased the human population in the area (Jairath et al., 2008). This has caused interference towards the wetland ecosystem of Ropar wetland which the groundwater is found to be contaminated by industrial, agricultural and resident activity in the region. The long-term usage of contaminated groundwater without treatment have poses serious threat towards the local resident in the Rupnagar district (Akhzer, 2016). Investigation have been going on to determine the causes of the resident getting health disorder in the Rupnagar district (Akhzer, 2016). The authority has confirmed that the contaminated groundwater by high level of heavy metal is the main reason the local residents getting health disorder (Asthana et al., 2015). This is due to the daily consumption of the contaminated groundwater by the local residents. The authority has also confirmed that the presence of high level of heavy metals in the groundwater are caused by the pollution generated from the agricultural and industrial activity at Rampar wetland (Jairath et al., 2008). In this report, the method used to determine the various

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summer season. The groundwater taken from the sampling sites were more alkaline in pH values when compare to nature groundwater without contamination. The groundwater contamination level are higher during summer season when comparing to winter season. This could be caused by the higher temperature during summer season causing the concentration of suspended particles that are found in groundwater to increase. Furthermore, the heavy metals level in the groundwater has also exceeded the limit stated in the guideline by the American Public Health Association (APHA) (Goel et al., 1987). The main reason of the heavy metals level of the groundwater has exceeded the prescript limit is caused by the coal fly ash dispose by the thermal power plant and cement factory at the Ropar wetland. Other than that, excessive use of fertilizer and pesticides for the agricultural activity near Ropar wetland are also one of the major sources of heavy metals contributor towards the high level of heavy metals in the groundwater quality.

3 Challenges to maintain the groundwater quality

3.1 Complicated research for groundwater quality

The research needed to determine the quality of the groundwater systems are very complicated to be perform. This is because the research of groundwater quality needs to involve various type of influencing factors, different type of hydrogeological conditions and different type of mechanisms formation (Anderson, 2014). All of the 3 factors must be included in the research when performing the groundwater quality research. Furthermore, the continuous human activity such as agricultural activity and industrial activity will make the groundwater quality research project to be more complex and complicated to be done (Li et al., 2016). This is due to the continuous pollution cause by agricultural activity and industrial activity towards the groundwater. The long-term activity of agricultural has caused the alteration of the groundwater circulation causing the deterioration of groundwater quality in the region. The unreasonable irrigation systems used for the agricultural activity is one of the main reasons towards the salinization of the secondary soil (Wu, Li, Qian and Fang, 2014). In addition, the increase human population furthermore increase the complexity to complete the research of the region groundwater quality (Li et al., 2016). This is because the number of populations of mankind in the region is closely related to the quality of the groundwater as humans are the major factor for the quality of the groundwater to decrease. The groundwater quality research also involves multidisciplinary section which include the hydrology, ecology, geochemistry, environmental sciences and geology sector (Scholz et al., 2000). Those discipline are required to be involves in the research for the groundwater quality which has causes the complexity to complete the groundwater quality research to increased making it an even complex research task to be completed.

3.2 Long-term project for groundwater quality research to be done

Groundwater quality research project is a long slow task that requires a lot of time and energy in order to be completed. This is because that there are many uncertainty involving when carrying out the groundwater quality research task. The social development happening in the region will affects the progress of the groundwater quality research. This is because that the groundwater quality research is closely related with the social development of the region (Davies and Mazurek, 1997). Therefore, it will affect the progress of the groundwater quality research and causing it to become a long-term task to be completed. The existence

of mankind are the main reason of the groundwater quality to be alter. This has further caused the alteration of groundwater quality and causing it to be more difficult to be reverse (Caliman et al., 2010). Groundwater can withstand higher amount of contaminants caused by human activity when comparing with surface water. However, once the groundwater is contaminated, the groundwater will be much difficult to be reverse (Caliman et al., 2010). In addition, the current existing technology and method used to discover the groundwater quality is yet to be fully develop causing the process takes to complete the groundwater quality research to be slow (Li et al., 2012). Thus, the accuracy of the current research maybe unacceptably inaccurate in different type of field conditions. Furthermore, some of the monitoring points of the contaminated area are very hard to access (Chen et al., 2006). This will cause low frequencies of monitoring causing the results obtained to be less accurate due to the difficulties in accessing the monitoring point.

3.3 Uncertainty during the research of groundwater quality

There are many uncertainty that might occur during the research of the groundwater quality. The research of groundwater quality is mostly fund by government and the changes in governing party will affects the progress of the groundwater quality research (Kanmani and Gandhimathi, 2013). Therefore, politic issues are a huge affection and uncertainty towards the research of groundwater quality. The changes of governing body will also follow by the changes of national policies which the project of ongoing groundwater quality research task might be force to be terminated (Kanmani and Gandhimathi, 2013). This is because the fund to carry out the groundwater research task is fund by the government and the lack of fund will cause the research to be very difficult to be continue. Thus, the research might not reach the outcome of expected or the pre plan stage which will affects the necessary steps or plan to protect or improve the quality of the groundwater. Other than that, there are also many uncertainties that might occur during the research of the groundwater quality. Quantifying anthropogenic effects are one of the uncertainty in the groundwater quality research task (GoroKhovskil, 2012). This is because judgments for quantifying anthropogenic effects are very subjective and different researcher doing the research might have different type of suggestion or conclusion (GoroKhovskil, 2012). In addition, the different types of equipment used in the groundwater quality research task will also cause uncertainty for the task (Igbinosa and Uwidia, 2018). This is because different type of equipment have different standard which the monitored data at the end might be affected. Moreover, the uncertainty in the groundwater quality research is also affected by the social development of the specific area. This is due to the social development in a specific area is full with unknown factor and uncertainties.

3.4 Higher qualification required for research team

The current research strategy used required the research team to have high related field of knowledge in order to carry out the groundwater quality research (Chukwu, 2008). Therefore, the research team are required to have relevant qualification and knowledge to perform a more accurate research. This has cause difficulties to researcher that are experience in practical but lack of theoretical and relevant knowledge to perform the research (Yao et al., 2015). The current situation of the groundwater quality research task require both practical and theoretical knowledge to perform the research. The groundwater quality research task require researcher that are expert in both practical and theoretical knowledge to perform the research in order to be able to resolve all the unexpected outcome throughout the research (Bala et al., 2006).

This is because the method used to carry out the research of contaminated groundwater cause by human activity is different from another hydrogeological research done in the past (Vaishaly et al., 2005). The groundwater quality research now involve a wide variety of research scope that must be included and carry out. This is to ensure that the results obtained will be more accurate. For instance, groundwater quality modeling is the new tools design for the research of groundwater quality (Yao et al., 2015). However, there are only very few expert researchers from university and institute are capable for carrying this modeling (Yao et al., 2015). This is because to run the modeling requires the researcher to have relevant knowledge and experience. Therefore, the modeling cannot be widely introduce and use for the research of groundwater quality as only very few amount of researchers are capable to carry out the modeling.

3.5 Open access of monitored data and cooperation

The monitored data for groundwater quality research are currently enclosed and the public are not able to access the data (Li et al., 2014). Data sharing for the monitored data towards the public and other agencies are very critical to protect the groundwater quality. The collected data from the monitored groundwater quality are only accessible by limited organizations from the governing body (Li et al., 2014). The agencies and organizations outside of the governing party will never get the data of the groundwater quality. The participation of the public and local agencies are very important and crucial to help in the research of the groundwater quality of the specific area. This is because the local resident and agencies know better regarding the condition of the groundwater quality (Guo et al., 2008). The involvement of the local agencies can improve the accuracy and standardize the data collected. In addition, most of the research carried out are only done by single organization without cooperating with others. This will cause the results obtained to be inaccurate and lack of consistency (Acharyya et al., 1999). Close cooperation between organizations of local agencies and governing authorities are crucial to conduct a better research. The local agencies and governing authorities can supervise each party that are involve in the cooperation to ensure that the research is done properly to achieve the desire outcome that are planned (Acharyya et al., 1999). Other than that, the cooperation between international organizations and other countries can helps in improving the accuracy of the research conducted. This can be achieved by exchanging data and methods used in conducting the research where the difficulties faced when conducting the research can be shared as well for further improve in the future research (Guo et al., 2008). Therefore, the open access towards the data obtained and cooperation are a huge challenges face in the current groundwater quality research project and must be revise for further improvement.

3.6 Advanced technologies and tools to improve the groundwater quality research

The current technologies and tools used for the groundwater quality research are less effective and the function are very limited (Kaur et al., 2017). However, the groundwater quality research depends heavily on advanced technologies and tools to conduct the research and obtained accurate and standardize data. Advanced tools such as modeling, remote sensing device and simulation are very crucial and plays an important role in achieving the accurate data for the research (Kelepertzis and Stathopoulou, 2013). Some of the monitoring points are in very deep jungle or rural area that are very difficult for the researcher to access (Kelepertzis and Stathopoulou, 2013). Thus, advanced technologies are important as it can helps in calibrating data for remote area that are difficult for the researcher to access. This can help the researcher to

constantly monitor the groundwater quality from offsite (Luo et al., 2011). The researcher can also understand the pattern of the groundwater quality through the advanced technologies and tools to predict the outcome of the pollution (Luo et al., 2011). This can helps preventing the pollution of groundwater to become worse and action can be taken at the first place for optimum outcome. In addition, the impacts of human activities towards the groundwater quality are rapidly increasing causing more and more groundwater to be polluted. Advance technologies and tools are required to reverse and prevent the groundwater from further pollution. Therefore, advanced technologies and tools are very important in this stage to monitor the groundwater quality and to take action in the first place when the groundwater are found to be contaminated.

3.7 Constant development in agricultural and industrial sector

The growing population of human being requires more development to ensure the supply of food source, daily needs can meet the required level of the current population (Stuckey et al., 2016). Thus, more industrial activity and agricultural activity needs to take place to ensure the survival of human being. The increase in agricultural activity and industrial activity has become one of the main source of contamination towards quality of the groundwater. This is due to the constant development in agricultural and industrial sector without proper planning in the disposal of waste (Achayya et al., 2005). The waste produced by industrial sector must be properly disposed to prevent the waste from leaching into the groundwater causing contamination and polluting the quality of the groundwater (Fendorf et al., 2010). Other than that, the irresponsible owner of the industrial factory that dispose the waste into the environment without proper treatment to reduce the cost have also seriously polluted the groundwater causing the quality of the groundwater to be unsuitable for human consumption (Garai et al., 1984). In addition, the fertilizer and pesticides used in the agricultural sector for plantation purpose have also caused the groundwater quality to reduce. The fertilizer and pesticide used are chemical products and will leached into the groundwater during raining season or when used in excess. The fertilizer and pesticide are very toxic and will cause the pH level in the groundwater to change which the quality of the groundwater will also be affected (Fausey, 2005). The nitrogen level in the groundwater will also increase causing the groundwater to be unsuitable for human consumption and those who consume might be toxified (Fausey, 2005). Therefore, the government must implement better enforcement in protecting the groundwater quality from deteriorating cause by the constant development in agricultural and industrial activity.

4 Solution to ensure the groundwater quality

4.1 Developing scientific tool to monitor the groundwater quality

An engineered scientific tools are required to monitor the condition of the groundwater quality from time to time. Such scientific tools can be used to obtained real time data of the contamination level from the groundwater. The current groundwater monitoring system adapt are less effective as the monitoring frequencies are low and the accuracy of the parameters obtained from the monitoring device now is less accurate (Vrba and Pekny, 1991). In addition, the period of monitoring the quality of the groundwater is short causing only very less data is obtained throughout the monitoring (Vrba and Pekny, 1991). Therefore, effective monitoring system must be implemented to safeguard the quality of the ground-

water from exceeding the prescribed contamination limit to ensure the health condition of mankind (Lee and Kwon, 2016). By observing the real time data of the groundwater quality, the quality of the groundwater can be ensured to be always on the optimum level and action can be taken once the data exceed the limit of the prescribed data (Nazir et al., 2015). The developed scientific tools can also help in monitoring those monitoring point that are difficult to access by mankind. This will improve the accuracy of the data collected as using real time monitoring scientific tools will increase monitoring frequencies. An effective monitoring tools are very important in maintaining the quality of the groundwater. This is because reversing the polluted groundwater is more complex and difficult than preventing the groundwater from polluted (Li, 2014). Therefore, preventing the groundwater from pollution is better than resolving the polluted groundwater. Thus, an effective monitoring network for groundwater quality must be implemented and carried out. Regularly maintenance also must be done to ensure the groundwater monitoring systems are always in the optimum condition and the accuracy of the data can be guaranteed.

4.2 Effort from the government in maintaining the groundwater quality

The government and the authorities play an important role to protect the groundwater quality from polluted. The attention from the government and authorities are mandatory to resolve the current situation of more groundwater being polluted by irresponsible individuals (Robins and Fergusson, 2014). The government and authorities can take action by enforcing strict rules and regulations to protect the groundwater quality (Robins and Fergusson, 2014). This is to ensure that the waste produced will be properly treated and disposed to prevent the waste from leaching into the groundwater (Robins and Fergusson, 2014). For those who breached or did not follow the rules and regulations must be punished by the law to prevent the same situation from happening again. The government can also set a standard guideline for the agricultural and industrial owner to follow to minimize the impact of both the industrial and agricultural sector from polluting the groundwater quality (Easter and Huang, 2014). Moreover, environmental impact assessment also can be introduced into the agricultural and industrial sector to protect the groundwater quality in the specific area (Easter and Huang, 2014). In addition, the government can encourage treating of wastewater produced and reuse the treated wastewater for other purpose (Randall and Iragavarapu, 1995). This will prevent the untreated wastewater from running off into the groundwater causing contamination. Reward such as reducing the tax amount can be given to those industrial and agricultural sector owners that comply with the new policy in protecting the groundwater quality (Randall and Iragavarapu, 1995). This will help in motivating the industrial and agricultural sector owner to work together to protect the groundwater quality. In addition, the support from the government to conduct the groundwater quality research tasks are also important in resolving the current groundwater quality issues. This is because huge number of funds are required in order to conduct the groundwater quality research task. Therefore, it is important that the government funds sufficient amount of budget to help the conduct of groundwater quality research task to be a success one.

4.3 Provide education to public regarding the importance of groundwater quality

Education is one of the key factor to solve the current groundwater quality condition. Through education, there are several benefits that can be achieved in protecting the groundwater quality (Woo and Kumar, 2019). One of the benefits is that education can create awareness among the public (Woo and Kumar, 2019). This can help the public to understand the importance of the

groundwater and the consequences brought by the contaminated groundwater. Thus, decreasing the rate of possible chances that the public might cause groundwater contamination by accident (Woo and Kumar, 2019). Next, education can create more educated professional to deal with the current contaminated groundwater and for the research purpose of groundwater quality (Woo and Kumar, 2019). Furthermore, professional that are educated can conduct a more accurate and precise groundwater quality research. In addition, strong background for the educated professional can overcome those uncertainty that they are facing throughout the groundwater quality research process. Lastly, educated professional are crucial in inspiring the development of science and technology sector (Woo and Kumar, 2019). The more developed science and technology sector will have a better impact on the development of new advanced technologies and tools. This will help in improving the quality of the groundwater research task as the use advanced technologies and tools in conducting the research will obtain a much accurate and precise data (Woo and Kumar, 2019). Therefore, it is suggested that the government and educational institute to fully support the growth of education sector and provide the locals with affordable education package.

4.4 Collaboration

Collaboration is a key to success in many different sector (Dohmann, 2016). It is also no different in the groundwater quality research project and protecting the quality of the groundwater. Collaboration with other organizations can help in improving the standard of the groundwater quality research project carried out (Robins and Fergusson, 2014). This is because collaboration is a win-win situation for both parties involving in the collaboration. One party can take the strength of another party to improve their own weakness throughout the collaboration to conduct the groundwater quality research (Luo et al., 2011). This will improve the efficiency and effectiveness of conducting the groundwater quality research. This strategy is very useful in helping undeveloped country that has no advanced technologies and tools to conduct the groundwater quality research task in the most effective way. In addition, cooperation is a good platform for organizations to keep them updated to the advanced technologies and tools in groundwater quality research task and protecting the groundwater quality (Caliman, Robu, Smaranda, Parvel, Gavrilescu, 2010). Therefore, it is recommended that the authorities or government body that are conducting the groundwater quality research project to collaborate with other organizations to ensure the quality of the data taken are precise and accurate.

4.5 Data sharing platform

Data sharing platform is an important step to improve the standard of the groundwater quality research project (Nussbaumer et al., 2016). There are many completed groundwater quality research plan data were not shared to the public. Keeping the data collected as private and confidential are creating a barrier that are limiting the improvement for the groundwater quality research (Woo and Kumar, 2019). This is because the data collected are only accessible by the conducting organization preventing other organizations from accessing and compare the result, technologies and tools used to conduct the experiment. It is suggested that all the groundwater quality research data are to be posted on a platform which can be easily accessed by the public for inspection purpose (Woo and Kumar, 2019). In addition, the data posted must be as frequent as possible which the sudden changes in the groundwater quality can be quickly taken action (Li, 2014). The data upload to the platform must also be as specific as possible which include all the required data such as the contaminant amount, contaminant site, type of contaminant and groundwater quality data. Therefore, creating a platform for the groundwater quality research data to be

able to access by public is mandatory in keeping the groundwater quality research project a success one.

5 Conclusion

Rapid development in agricultural sector has increased the chemical substances used in the sector. Excess used of those chemicals' substances lead the chemical substances to leach into the groundwater. The affected groundwater will require more cost to treat the groundwater. The lack of advanced technologies and tools for researching of groundwater quality is one of the reasons that the quality of groundwater is getting worsen. The current technologies available to conduct the groundwater quality research is outdated and the data collected are not precise. The promote of education to the public will also encourage more people to help in protecting our environment and inspire more people to develop the advanced technologies for the groundwater quality research. However, government plays an important role in order to resolve the current situation of the groundwater quality. The government must enforce stricter rules and regulations to halt the pollution towards the groundwater. Other than that, the government can collaborate with other organizations that are expert in conducting the groundwater quality research tasks. In addition, all of the public should be allowed to access the platform to check for the latest groundwater quality and be aware of the current situation of the groundwater quality.

Declaration of competing interest

The authors declare no known competing interests that could have influenced the work reported in this paper.

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