Pertanika J. Sci. & Technol. 27 (4): 2265 - 2279 (2019)

SCIENCE & TECHNOLOGY

Journal homepage: http://www.pertanika.upm.edu.my/

Prediction of Groundwater Contaminants from Cattle Farm using Visual MODFLOW

Mohammad Nazri Ebrahim, Hasfalina Che Man*, Mohamed Azwan Mohamed Zawawi and Muhammad Hazwan Hamzah

Department of Biological and Agricultural Engineering, Faculty of Engineering, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia

ABSTRACT

Livestock operation activities such as cleaning operation, feeding, milking and manure disposal are potential sources of contaminants into nearby surface and groundwater. In this study, the number of wastes generated from a cattle farm in Ladang 16 UPM, Serdang Selangor was estimated. Two monitoring wells were constructed at the site for groundwater quality monitoring assessment. The concentration of pollutants such as Potassium, Nitrate, and Copper was used in the simulation as an initial waste state. The simulation was conducted using Visual MODFLOW Software to predict the contaminants in groundwater. The aim was to predict the concentration of the pollutants distributed in groundwater and surface water sources in 365 days. Results of MODFLOW simulation showed that the flow of groundwater was in the direction towards the pond. The concentrations of Potassium, Nitrate, and Copper were predicted to accumulate in the groundwater to the pond within a year but the values were still below the drinking water standard. The groundwater contaminants could be due to seepage from the manure storage basin through subsoil into the shallow aquifer.

Keywords: Cattle farm, groundwater contaminants, monitoring well, visual MODFLOW

INTRODUCTION

The development in urbanization causes the increasing demand for water that has influenced groundwater to become one of the significant sources. Agriculture field development such as milk production, fertilizer disposal, livestock manure, and poultry production is currently growing rapidly. Nutrients enrichment such as

ARTICLE INFO

Article history:
Received: 07 February 2019
Accepted: 19 July 2019
Published: 21 October 2019

E-mail addresses:
emohammadnazri@gmail.com (Mohammad Nazri Ebrahim)
hasfalina@upm.edu.my (Hasfalina Che Man)
mohdazwan@upm.edu.my (Mohamed Azwan Mohamed Zawawi)
hazwanhamzah@upm.edu.my (Muhammad Hazwan Hamzah)
* Corresponding author

ISSN: 0128-7680
e-ISSN: 2231-8526

Nitrate, Copper, and Potassium. which are recognized as pollution, could result in an adverse effect on groundwater and surface water ecosystem (Adeoye et al., 2017). The main sources of nitrate pollution in livestock areas include livestock yard (that includes barnyards, holding areas, and feedlots), manure storage lagoons, and cropland receiving manure (Harter et al., 2002) areas which are the main sources of animal wastes within livestock facilities. Livestock waste contains nitrogen in both inorganic and organic compounds. The inorganic fraction is equivalent to the N emitted in urine and is usually greater than the organic one. Microbial action decomposes wastes containing organic nitrogen into ammonia, which is then converted into nitrite and nitrate. Nitrite is effectively oxidized to nitrate, so nitrate is prevalent in decayed wastes (Kumar, 2013). Nitrate can easily migrate through soil layers as the Nitrate-containing compound is generally soluble (Gollenhon & Caswell, 2000). Improper management of these compartments results in manure loss, which then leaches into the subsurface. The extent of leaching is dependent upon the climate, soil type, present nitrogen mass and hydraulic loading. Studies document nitrate leaching to groundwater under varying conditions, causing nitrate contamination of groundwater. Additionally, various studies from different regions in the United States and somewhere else, record manure effects to groundwater quality (Redding, 2016; Yamin et al., 2015). There are documented examples of manure impacts on groundwater quality in Washington State. In the Lower Yakima Valley, an U.S. Environmental Protection Agency (2011 and 2013a, 2013b) investigation concluded that dairy manure contributed to groundwater contamination of the local unconfined aquifer. There is currently no documented literature available on groundwater monitoring pollutants in Malaysia.

Based on the toxicity, the maximum contamination level (MCL) for drinking water has been set at 50 mg/L nitrate ion (NO_3) (equivalent to 11.3 mg/L nitrate-nitrogen, NO_3-N) by the World Health Organization (WHO), and 10 mg/L NO_3 – N by the U.S. Environmental Protection Agency (2003) and WHO (2004). Thus, nitrate is considered as an indicator parameter for assessing the extent of pollution in the vicinity of a facility. Other parameters that indicate pollution include ammonia, nitrite, pH, TDS, P, SO_4^{2-}, and alkalinity (Sahoo et al., 2016).Therefore, understanding of nitrate dynamics and other pollutants is important for managing and controlling potential groundwater pollution.

Groundwater monitoring provides a direct assessment of impacts to groundwater quality from land uses and is an important tool for determining how effective manure management practices are being implemented and thus minimizing impacts on groundwater. Groundwater monitoring is also an effective verification tool used to help evaluate the fate and transport of nitrate and other pollutants in the subsurface (Redding, 2016). Effective monitoring includes site selection criteria along with a selection of sampling points and parameters which can identify the source and extent of the contamination (Sahoo et al., 2016). Monitoring also provides an assessment of manure management practices.

Many groundwater models are available to assist in projecting impacts to groundwater quality. Some require intensive site-specific data, which typically generate more accurate results. The U.S. Geological Survey (USGS) developed MODFLOW in 1984 as a standard three-dimensional, finite difference groundwater model suitable for larger watershed assessments (Mc Donald & Harbaugh, 1984). It was originally developed in 1984, but has since been modified from being solely a groundwater flow model to now include contaminant transport, unsaturated zone transport, and water use by vegetation, as well as other capabilities. MODFLOW is a data-intensive model that requires accurate knowledge of environmental conditions. Visual MODFLOW (Waterloo Hydrogeologic, Kitchener, Ontario, Canada) is an application available to simulate groundwater flow in a wide range of natural systems. It is also able to determine the groundwater behaviour in connection with the river and lake as well as the estimation of contaminants transportation. The groundwater flow and contamination transport models are important in determining the sustainability of groundwater. For the purpose of modeling, data such as rainfall data, recharge rate, evaporation rate and parameters such as the concentration of contaminants are needed for estimating the transportation of contaminants by the groundwater.

Saghravani and Mustapha (2011) conducted a study on the movement of phosphorus leaching into groundwater using MODFLOW to predict subsurface and surface migration of pollution within 10 years. In addition, the application of MODFLOW to predict the pollution from poultry farm was conducted by Aderemi et al. (2014). The results of their study showed the simulation and prediction of phosphorus and nitrates concentration in the aquifer if indiscriminate and over application of poultry manure to Minna soil was continued. The simulation by MODFLOW was able to analyse the direction flow of the contaminants in groundwater. The MODFLOW can be used as a screening tool to indicate when groundwater is at risk of contamination. These tools provide an estimate of impacts on groundwater quality for the management of water resources and environmental protection.

The purpose of this study is to monitor the contaminants in groundwater at Ladang 16, UPM due to livestock operation activities. The sources of pollution are located on an elevated hillside and the spread of pollutions is expected to be more distributed as the groundwater carries the pollutant downhill (Saghravani, 2009). A river and lake were located less than 10 m from the source of pollution and thus needed to be monitored. Simulation using Visual MODFLOW is to predict the fate and transport of contaminants produced from the manure storage basin on groundwater quality on surface water and groundwater quality.

MATERIALS AND METHODS

General Description of Study Area

This study was conducted at Ladang 16, Universiti Putra Malaysia (UPM), Serdang, Selangor Darul Ehsan located at 2.991975° N, 101.733170° E. The 150,000 m^2 study area is located within elevation range between 52.5 m and 40 m above the Mean Sea Level (Figure 1). The population of dairy cattle and beef cattle in Ladang 16 was 43 and 135, respectively. The manure produced by a single cow was approximately 5-10 kg per day. The water used for cleaning purposes was estimated from 25 L to 30 L for each cattle per day. The wastewater from cleaning flowed directly into a retention pond. Two monitoring wells were constructed about 50 m to the cattle farm at A and next to a retention pond at location B (Figure 1). The monitoring wells MW1 and MW2 were located at 2.993113°N, 101.732°E and 2.99248°N, 101.7332°E.

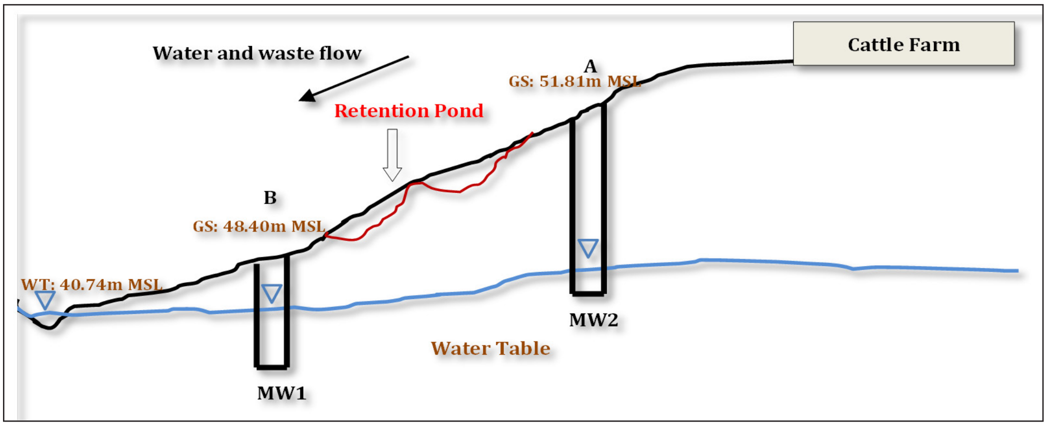


Figure 1. Cross-section view of the study area

Determination of Well Location

The well lithology and groundwater table were determined prior to the drilling of the borehole. Before that, a resistivity test was conducted to locate suitable areas for monitoring wells. The water samples were collected from MW1, MW2, pond, and river to be analysed in the laboratory for selected contaminants such as Copper, Potassium and Nitrate and *in-situ* groundwater analysis was measured at the monitoring well such as conductivity and pH by YSI meter.

Soil Resistivity Test

The soil resistivity was conducted to determine the geology type and possible groundwater storage for the area. This analysis was able to transversely map the soil layer based on the resistance values. A higher resistance was considered as hard rock and lower resistance was potentially to have more water. The Wenner array method was applied in this study. The experimental set-up of resistivity is shown in Figure 2. The cables were pulled to 100m to the left side and 100m to the right side from the centre at the Resistivity A and Resistivity B, respectively. The soil resistivity is calculated and recorded by ABEM Terrameter System. When all possible combinations of pairs of electrodes had been tested, the field data were processed using MODFLOW. Figure 2 shows the resistivity test at two different locations; location A is for MW2 and location B for MW1.

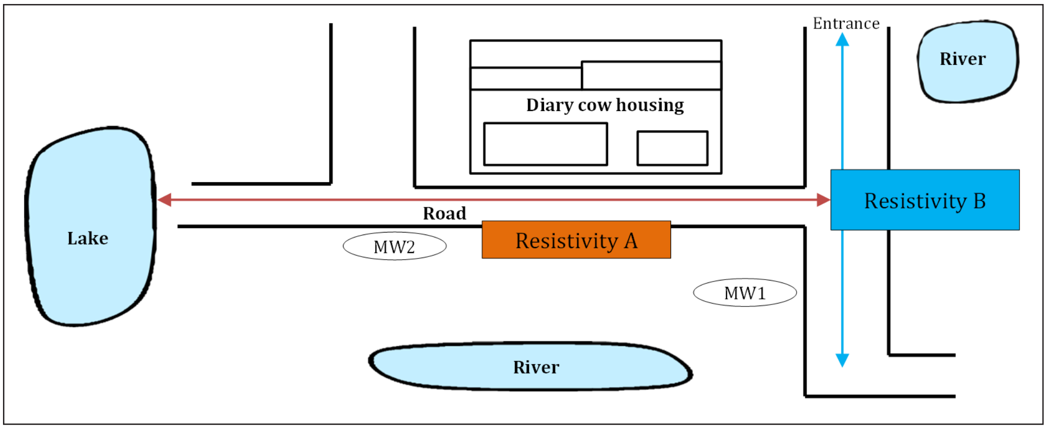


Figure 2. Resistivity test location A and B

Soil Sampling and Installation of PVC Pipe in the Borehole

Soil samples were collected at depths of 1.5 m, 3.0 m, 4.5 m, 6.0 m, 8.0 m and 10 m from each monitoring well during the borehole drilling. The 4 inches diameter of PVC pipes were installed as the main structure of the monitoring wells. The soil samples were classified by the Pipette method.

Simulation using Visual MODFLOW

The input data such as precipitation, evapotranspiration, river data and well lithology were collected through field measurement and from literature. The data required for MODFLOW simulation is summarized in Table 1.

Table 1
Data requirement in visual MODFLOW 4.2

Data	**Value**	**References**
Precipitation	2996.3 mm	(Saghravani et al., 2013)
Soil conductivity	Layer1(2.0 E-4 m/s) ,Layer2(3.2E-5 m/s), Layer 3(3.2E-10 m/s)	Environment base software.
Data of existing wells surrounding the site	Well Identification (Sel 1, Sel 49 and Sel 50)	Minerals and Geoscience Department Malaysia
Evapotranspiration	1498 mm	(Saghravani et al., 2013)

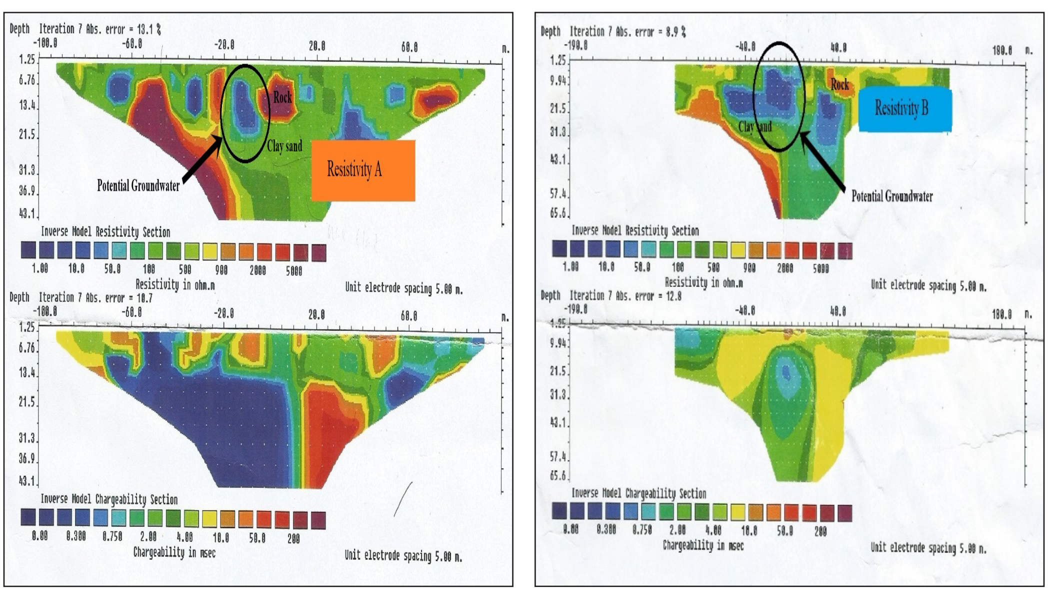
Water Quality Analyses

The portable sampler was used to collect groundwater at 10 m depth. The YSI portable meter was used to measure the pH, DO and turbidity. The groundwater and surface water (from lake and river) samples were collected from January 2017 to February 2017 for every two weeks. The water quality analysis was measured using DR/4000 Spectrophotometer within 190-1100 nm wavelength to measure the concentration of the nitrate, iron and sulphate in the water sample. Subsequently, water samples were also analysed using Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) for heavy metals to obtain potassium and Copper concentration.

RESULTS AND DISCUSSION

Resistivity Test

As per results in Figure 3a, it was observed that the lower value of ohm-m indicates the presence of water at the depth of 10 m below the soil surface. A similar observation was reported by Meena (2011) that at -10 m from the central region of resistivity there were blue spots indicating groundwater with resistivity of 1 ohm-m. Figure 3b shows the availability of water at -40 m from the central region of resistivity. The resistivity value of topsoil was between 100-500 ohm-m (Meena, 2011). It shows that the type of composition is between clay sand and gravel mixture. The soil type provides a baseline for the selection of monitoring well, in addition to the water availability and the hardness of the soil type



(a) (b)

Figure 3. (a) Resistivity A to locate monitoring well 2 (MW2) and (b) Resistivity B to locate monitoring well 1(MW1)

beneath. Plus, the results for both resistivity A and resistivity B were compared with well log data from Pipette result along 10 m depth. The result is shown as the labelled structured.

Well Lithology from Pipette Method

The results from the Pipette method were calculated and the textural analysis based on the textural classification system. The result indicates that the topsoil consisted of 60% sand particles, 30% clay and 10% silt and the texture was sandy clay loam. The interception in the textural analysis was taken as the result of the soil classification. The result of soil classification was calculated using soil texture calculator. These results had been included as part of the inputs required by MODFLOW software such as the soil conductivity.

Water Quality Analysis

Based on Table 4, it shows the presence of contaminants of nitrate, copper and potassium in the river and pond that were suspected to be accumulated based on groundwater flow in Figure 1. Table 2 and Table 3 present the results of water quality in MW 1 and MW2. The results of the concentration of Potassium, Nitrate, and Copper in MW1 and MW2 were used in Visual MODFLOW to simulate the flow of transport in 365 days.

Table 2
Results of field analysis of groundwater quality

Parameter	**Concentration in MW1**	**Concentration in MW2**
Temp (°C)	28.4±0.85	27.8±1.25
DO (mg/L)	1.50±0.32	1.85±0.26
SPC (μs/cm)	189.73±11.9	50.7±3.25
TDS (mg/L)	123.18±6.22	32.83±2.22
Salinity (ppt)	0.088±0.005	0.02±0.0
pH	6.91±0.07	6.80±0.12

*values are means of the repeated experiments ± standard deviation

Table 3
Results of laboratory analysis of groundwater quality

Parameter	**Concentration in MW1**	**Concentration in MW2**
Turbidity (NTU)	*11.63±9.39	*7.10±2.02
Chemical (Inorganic)		
Ammonium (mg/L)	*5.80±1.33	*1.10±0.12
TSS (mg/L)	*207±113.76	*66.25±68.28
Nitrate (mg/L)	*1.43±1.85	*1.28±1.10
Sulphate (mg/L)	*15.03±4.94	*1.73±0.39
Iron (mg/L)	*2.78±1.56	*0.81±0.36
Potassium (mg/L)	7.09	5.26
Heavy Metals		
Copper (mg/L)	0.13	0.088
Lead (mg/L)	ND*	0.016
Microbiological		
Fecal Coliform (Cfu/100ml)	2	10

*ND= not detected; *values are means of the repeated experiments ± standard deviation

Table 4
Result of field Analysis of surface water quality

Parameter	Concentration in Pond	Concentration in River
Field Analysis		
Temp (°C)	*27.3±0.94	*27.1±1.37
SPC (μs/cm)	*88.48±12.60	*72.5±14.11
TDS (mg/L)	*57.36±8.13	*49.46±13.0
Salinity (ppt)	*0.04±0.01	*.03±0.01
Laboratory Analysis		
Turbidity (NTU)	*27.1±17.35	*13.45±14.29
Nitrate (mg/L)	1.7±1.95	1.4±1.74
Copper (mg/L)	0.091	0.075
Potassium (mg/L)	2.49	0.726
Fecal Coliform(Cfu/100ml)	>100	>50

The concentration of contaminants of Potassium, sulphate, and copper was high in MW1 as the source of pollution expected from the waste storage basin and the cattle farm. The concentration of contaminants in MW2 is much lower than MW1 presumably due to the infiltration effect of pollutants into the groundwater and downwards into the rivers and pond. Some of the waste could flow as a runoff from the higher elevated hillside to the river and pond (Figure 1). The contamination of potassium, nitrate and copper were measured inside both wells.

Figure 4 shows that the Potassium values were higher in MW1 and MW2 with 7.09 mg/L and 5.26 mg/L, respectively. The nitrate concentrations were at 3.28 mg/L in monitoring well 1 and 2.38 mg/L in monitoring well 2. The nitrate concentration was

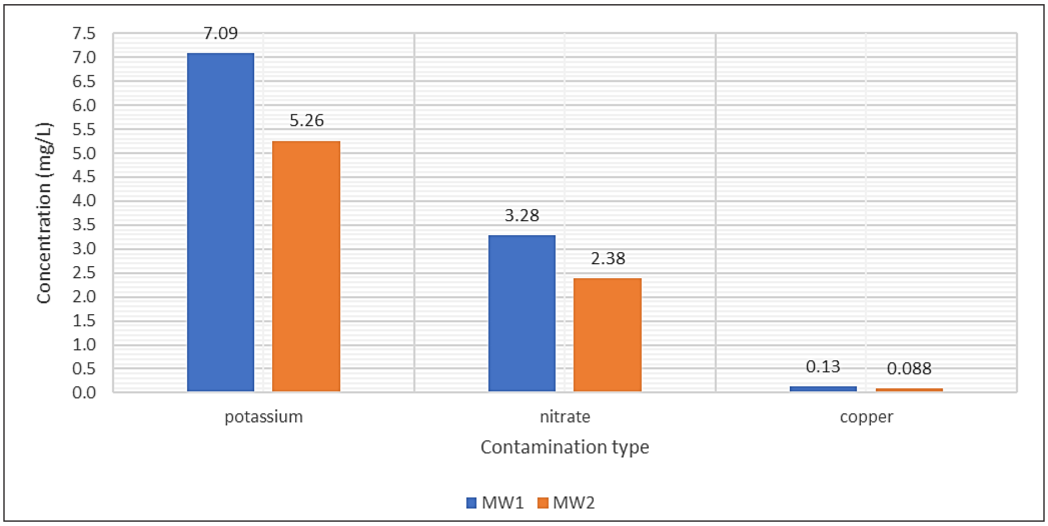


Figure 4. Concentration of contamination at MW1 and MW2

below the limits for drinking water. The contamination of copper was also low in MW1 which was 0.13 mg/L compared to 0.088 mg/ L inside MW2. The reduction of contaminant concentration from MW into pond and river indicates the lesser pollutant flows from higher elevated area to low. The results of contaminants, however, were higher in MW1 compared to MW 2.

Simulation using Visual MODFLOW

Generally, Visual MODFLOW predicts the flow and concentration of selected contaminants based on the sources release to the groundwater or aquifer during a simulation. Figure 5 shows the flow of groundwater was moving downwards in the direction of the pond. The result of the groundwater flow had proven to be in the same direction as shown in the cross-section view of the study area in Figure 1.

Validation is the process of evaluating the final product to check whether the software meets the expectations and requirements. In this study, validation was done by collecting water samples at MW1 and MW2 and analysing groundwater contaminants for Copper, Nitrate and Potassium after 1 year. Regression analysis was done to compare the observed concentration and predicted concentration from the model. The result was shown in Figure 9 for both monitoring wells MW1 and MW2. The correlation shows that R^2 is 0.8651 and 0.794 for MW1 and MW2, respectively. The coefficient of determination, R^2, is a measure of how well the regression model describes the observed data. From the R^2 value, this study shows that the predicted model was in a good fit with the observed data because R^2 shows the positive relationship and the nearer is R^2 to 1, the more accurate is the regression model (Schneider et al., 2010).

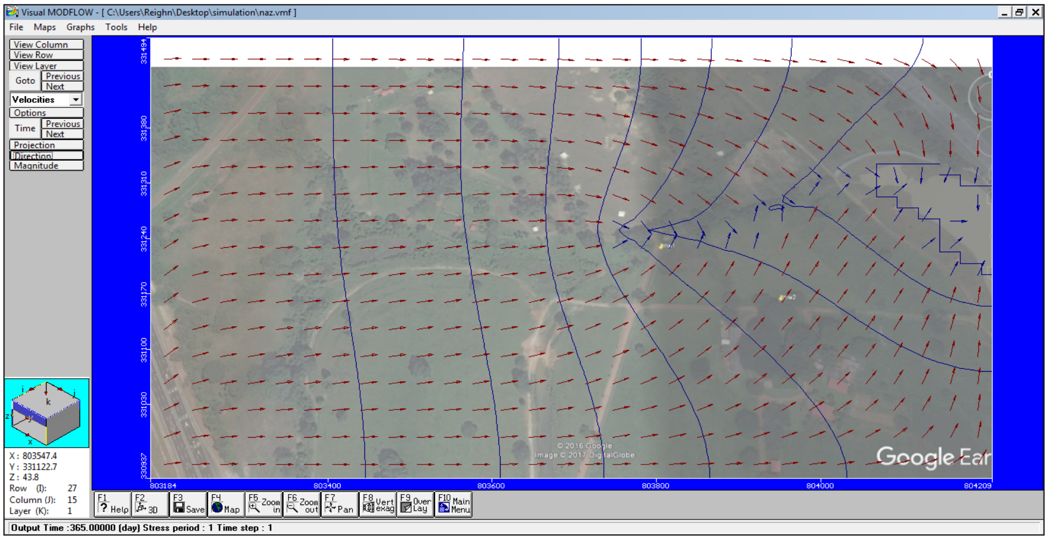


Figure 5. Groundwater flows in Ladang 16, UPM

Concentration of Copper

Figure 6 shows the predicted flow of Copper into the pond and the concentration was expected to be low in the area of cattle farm which was less than 0.0557 mg/L after 365 days due to the flow of groundwater that was distributed based on the high elevation to low elevation. The colour contour shows the flow and amount of copper within 365 days. As a result, copper was relatively low as it behaves in a different way from other heavy metals considered. Copper has been known to have good affinity with clay soil and can react with other chemicals in the soil to produce another compound (Aderemi et al., 2014). The distribution of concentration of Copper versus time is shown in Figure 6. The pattern of the graph shows that copper is predicted to decrease through time from its decrease initial concentration as it flows into the lake for 365 days. In conclusion, 0.0557 mg/L of copper is relatively low because the concentration for the toxicity of the groundwater affected is 20-50 mg/L.

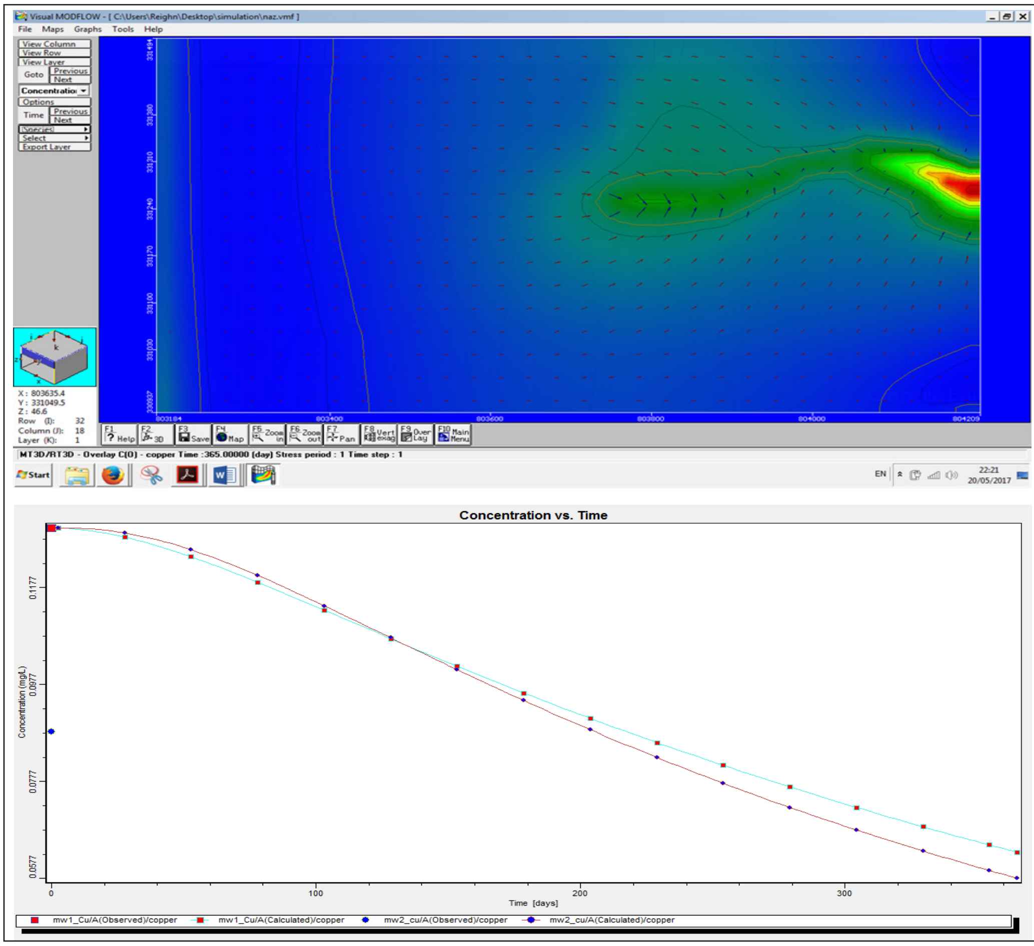


Figure 6. Copper Distribution in 365 days and its concentration by time

Concentration of Potassium

Potassium is available in manure and highly available in plants and can be used similar to K fertilizer application. Most potassium (> 70%) is excreted in urine, indicating the high solubility of the excreted K. Figure 7 shows the contour of the potassium distribution in 365 days, with the blue contour indicating the value of concentration was less than 3.15 mg/L. The potassium contamination was predicted to be at a high concentration level in the lake area. Within 365 days, the simulation showed the concentration of potassium was still below limits to give negative impacts to the environment.

Figure 7 shows the initial value of potassium was 7.15 mg/L and the concentration of potassium decreased with time. The lower concentration of potassium was predicted to be 3.15 mg/L and did not exceed the high level of standard concentration of potassium which was 5.2 mg/L. In conclusion, this groundwater can only be used for livestock operations such as drinking and cleaning because it will not harm the livestock yield, but it is not recommended to be used as drinking water because the concentration of potassium exceeds the standard concentration of 2.5 mg/L (WHO, 2009).

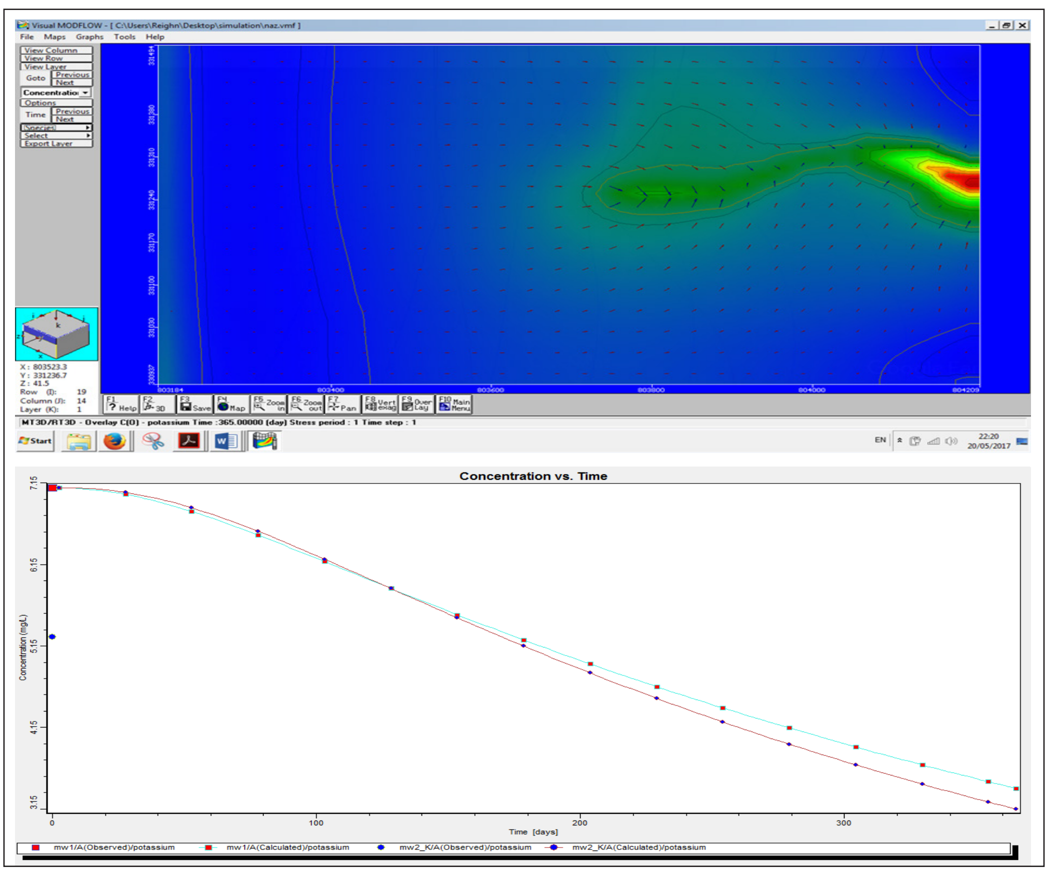


Figure 7. Potassium distribution in 365 days and its concentration by time

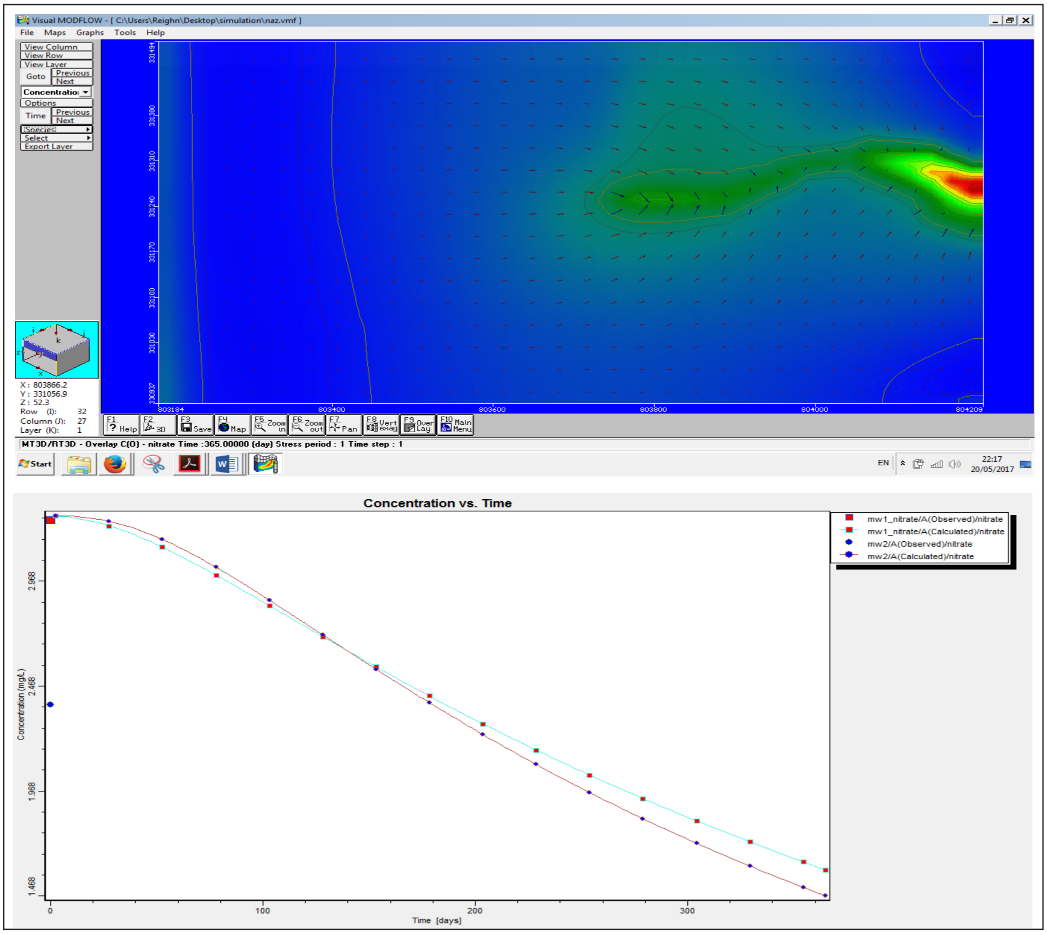


Figure 8. Nitrate distribution in 365 days and its concentration by time

Concentration of Nitrate

As shown in Figure 8, the nitrate concentration was flowing directly into the lake during the entire 365 days. The distribution of nitrate was predicted to be low in monitoring wells 1 and 2 in 365 days and the result of concentration showed that the nitrate decreased with time. Figure 9 shows the nitrate was 1.466 mg/L after 365 days compared to the initial concentration which is 3.28 mg/L. The result shows the pollution that was produced in the cattle farm had no adverse effect on the environment of groundwater because the concentration of nitrate did not exceed 4 mg/L.

In conclusion, the result of copper, potassium, and nitrate is relatively low in Ladang 16, UPM and the groundwater source can only be used for livestock operation and crop irrigation. The results indicate that within a year, the concentrations of nitrate and potassium in groundwater decreased by 55% and Copper decreased as well.

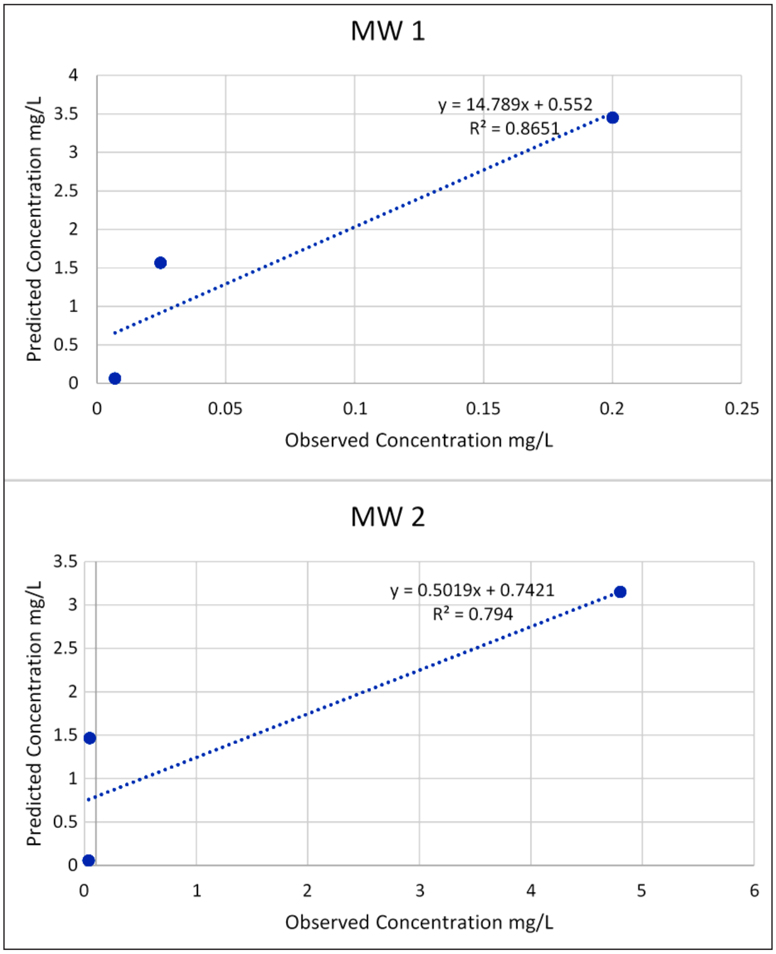


Figure 9. Predicted Concentration vs Observed Concentration

CONCLUSION

In this study, the quantity of waste generated from cattle farm has been estimated. Results from this study are useful for technical groundwater management to clearly identify suitable borehole locations for long term groundwater monitoring. In addition, this result can provide guidelines to determine suitable location for groundwater monitoring. Visual MODFLOW simulation is able to predict the pollutants fate in Ladang 16, UPM. It was observed that the concentrations of Copper, Potassium, and Nitrate were reduced within 365 days. Although the result showed that the pollution was low, actions in controlling and management of waste from any activities need to be done immediately. Furthermore, the result of simulation can be useful to assist the authorities in groundwater management as the main source of water supply in the future.

ACKNOWLEDGEMENT

The authors would like to acknowledge the financial support provided by TWAS (The World Academic Sciences) Research Grant (15-316 RG/ENG/AS_C/TWAS2015). Also thank to Mr. Tarmizi Ishak at University Agriculture Park for his assistance.

REFERENCES

Adeoye, P. A., Man, H. C., Soom, M. A. M., Thamer, A. M., & Oluwakunmi, A. C. (2017). Contaminants leaching from fresh poultry waste: a lysimeter study on sandy soils under tropical conditions. *Environment and Pollution*, *6*(1), 38-51.

Aderemi, P. A., Man, H. C., Soom, M. A. M., Mohammed, T. A., & Oluwakunmi, A. C. (2014). Groundwater quality of shallow wells on Nigerian poultry farms. *Polish Journal of Environmental Studies*, *23*(4), 1079-1089.

Gollehon, N., & Caswell, M. (2000). Confined animal production poses manure management problems. *Agricultural Outlook,* (274), 12-18.

Harter, T., Davis, H., Mathews, M. C., & Meyer, R. D. (2002). Shallow groundwater quality on dairy farms with irrigated forage crops. *Journal of Contaminant Hydrology, 55*(3-4), 287-315.

Kumar, L. (2013). A study of nitrate contamination in ground water of Delhi, India. Asian *Journal of Water, Environment and Pollution, 10*(2), 91-94.

McDonald, M. G., & Harbaugh, A. W. (1984). *A Modular Three-Dimensional Finite-difference Ground-Water Flow Model* (No. 83-875). Reston, VA: US Geological Survey,.

Meena, A. (2011). *Exploration of Ground Water using Electrical Resistivity Method* (Doctoral dissertation). National Institute of Technology Rourkela, Odisha, India.

Redding, M. (2016). *Manure and Groundwater Quality: Literature Review* (Publication No. 16-03-026). Washington, DC: Department of Ecology.

Saghravani, S. R. (2009). *Prediction of Phosphorus Concentration in an Unconfined Aquifer Using Visual Modflow* (Doctoral dissertation). Universiti Putra Malaysia, Selangor, Malaysia.

Saghravani, S. R., & Mustapha, S. (2011). Prediction of contamination migration in an unconfined aquifer with visual MODFLOW : a case study. *World Applied Sciences Journal, 14*(7), 1102-1106.

Saghravani, S. R., Yusoff, I., Mustapha, S., & Saghravani, F. S. (2013). Estimating groundwater recharge using empirical method : a case study in the tropical zone. *Sains Malaysiana, 42*(5), 553-560.

Sahoo, P. K., Kim, K., & Powell, M. A. (2016). Managing groundwater nitrate contamination from livestock farms: implication for nitrate management guidelines. *Current Pollution Reports, 2*(3), 178-187.

Schneider, A., Hommel, G., & Blettner, M. (2010). Linear regression analysis: part 14 of a series on evaluation of scientific publications. *Deutsches Ärzteblatt International, 107*(44), 776-782.

U.S. Environmental Protection Agency Science Advisory Board. (2011). *Reactive Nitrogen in the United States: An Analysis of Inputs, Flows, Consequences, and Management Options* (Report No. EPA-SAB-11-013). Washington, DC: EPA Science Advisory Board.

U.S. Environmental Protection Agency. (2003). *National Primary Drinking Water Standards*. Washington DC: Environmental Protection Agency.

U.S. Environmental Protection Agency. (2013a). *Relation between Nitrate in Water Wells and Potential Sources in the Lower Yakima Valley, Washington* (Report No. EPA-910-R-13-004). Washington, DC: Environmental Protection Agency.

U.S. Environmental Protection Agency. (2013b). *Monitoring Well and Installation and Data Summary Report, Lower Yakima Valley, Yakima County, Washington*. Washington, DC: Environmental Protection Agency.

World Health Organization. (2004). Recommendations: nitrate and nitrite. In *Guidelines for drinking-water quality* (3rd Ed.) (pp. 417-420). Geneva, Switzerland: WHO.

World Health Organization. (2009). *Potassium in Drinking-Water*. Geneva, Switzerland: WHO Document Production Services.

Yamin, M., Nasir, A., Sultan, M., Ismail, W. I. W., Shamshiri, R., & Akbar, F. N. (2015). Impact of sewage and industrial effluents on water quality in Faisalabad, Pakistan. *Advances in Environmental Biology, 9*(18), 53-59.