

## Influence of Potassium on Sapric Peat under Different Environmental Conditions

Syafik Akmal Mohd Tajuddin<sup>1\*</sup>, Junita Abdul Rahman<sup>2</sup>, Nor Haakmal Abd Rahim<sup>3</sup>, Radin Maya Saphira Radin Mohamed<sup>4</sup>, Dr Adel Ali Saeed Abduh Algeethi<sup>5</sup>

<sup>12345</sup>Faculty of Civil and Environmental Engineering, Universiti Tun Hussein Onn Malaysia, 86400 Batu Pahat, Johor.

E-Mail: maya@uthm.edu.my

**Abstract:** Potassium is mainly present in soil in the natural form known as the K-bearing mineral. Potassium is also available in fertilizer as a supplement to plants and can be categorized as macronutrient. The application of potassium improves the texture and structure of the soil beside to improves plant growth. The main objective of this study was to determine the concentration of potassium in sapric peat under different conditions. Physical model was used as a mechanism for the analysis of the experimental data using a soil column as an equipment to produce water leaching. In this investigation, there were four outlets in the soil column which were prepared from the top of the column to the bottom with the purpose of identifying the concentration of potassium for each soil level. The water leaching of each outlet was tested using atomic absorption spectroscopy (AAS). The results obtained showed that the highest concentrations of potassium for flush condition at outlet 4 was 13.58 ppm. Similarly, sapric under rainwater condition recorded the highest value of 13.32 and 12.34 ppm respectively at outlet 4 for wet and dry condition. However, the difference in Sapric, rainwater and fertilizer category showed that the highest value for the wet condition was achieved at outlet 2 with 13.99 ppm while highest value of 14.82 ppm was obtained for the dry condition at the outlet 3. It was concluded that the outlets in the soil column gave a detailed analysis of the concentration of potassium in the soil which was influenced by the environmental conditions.

### 1. Introduction

Peat is a type of soil which is formed by the decomposition and accumulation of organic matter which exists on the earth surface over thousands of years ago. Peat have the characteristic potentials to retain water and air and as a result are known to be waterlogged especially in the terrain where there is poor drainage system. Peat soil is the accumulation of pure organic material which contains at least 65 % of organic matter or less than 35 % mineral content [1]. According to estimation, there are about 2.4 million hectares of peat in Malaysia where major portions of hectares of about 1.5 million hectares are located in Sarawak alone [2]. The deposition of the peat soil may occur in three different geographical conditions which are the lowland coastal swamps, inland swamps and the valleys having high altitude which are free from draining situations and highland swamps [1]. Organic matters in peat also contains carbon derived from dead and decomposed plant remains. The high organic content is a significant feature of peat soil which normally has the appearance of a



brownish black colour [3]. The other physical properties of peat includes decomposition degree, water content, specific density and bulk density [4].

According to United State Department of Agriculture (USDA, 1999) classification of peat has been narrowed to 3 categories which are fibric, hemic and sapric peat soils. Fibric peat consists of high organic fiber content with more than 66 % low degree of humification. As compared with fibric peat, the sapric peat has low organic fiber content usually less than 33 % degree of humification and consists of most decomposed materials. However, the behaviour of hemic peat serves as the intermediate between the fibrous and sapric peats [5]. The level of peat decomposition can be preliminary measured by using Von Post Scale which is expressed in terms of a ten class scale (H1 to H10) on which higher numbers can be used to indicate stronger peat decomposition. The degree of decomposition is related to the deposition of peat in the environment and the types of decomposed peat forming plants [3]. According to Haut [6], sapric peat usually contains highly decomposed materials and changes from very dark grey to black appearance. The original plant fiber is mostly lost and the water retention capacity is also less than fibrous or hemic. In addition, sapric peat also contains deposits which are likely to exist at lower void ratio and display lower permeability, lower compressibility, lower friction angle and also at a higher coefficient of earth pressure at rest.

Malaysia is one of the largest producers of palm oil in the world with an estimated area of 50,000 km<sup>2</sup> involved with oil palm cultivation. Since in the 1990s, about 25 % of peatland area in Malaysia has been converted to oil palm plantations to satisfy the demand for crude palm oil [7]. However, most farmers prefer to use chemical fertilizer as the most convenient and effective method to increase food production without considering the effect of the application on the soil and the impact on environmental quality [8]. Chemical fertilizer enhances the soil faster, much cheaper and can absorb the nutrients immediately [9] compared to the organic fertilizer [10].

Application of fertilizer to the soil helps to nourish the plant with supply of nutrients. Fertilizer contains three major plant nutrients which are the nitrogen, phosphorus and potassium widely known as N-P-K. Potassium is one of the six essential nutrients required for plant growth and reproduction. Potassium is categorized as macronutrient similar to nitrogen (N) and phosphorus (P). The primary source of potassium is traditionally from ash remains after burning wood, but due to the factor of increasing demand, the production of potassium is being obtained from natural salt deposits, salt lakes and brines. Potassium is an important nutrient which is usually transported in the plant at a high concentration that occurs in the vascular tissues such as the phloem tissue for the supply of nutrients to the plant [11]. Potassium can increase crop yield and improves quality of crop production in terms of application and the supply of nutrient in the soil to enhance plant growth beside acts as an enzyme that serves as catalysts for chemical reactions. However, potassium acts in the form of positive ion (cation) K<sup>+</sup> as a mechanism of plant absorption [12]. According to Zörb [13], the application of lower fertilizer K in the context of unbalanced fertilization may result in a significant depletion of K reserves available in the soil and thus could lead to the decrease in soil fertility. However, excessive use of fertilizer may affect groundwater quality as a result of pollution.

Generally sapric peat is in the deepest position which found 3 meters down in the peatland floor when viewed from the soil surface. Sapric peat or mature peat, has a high content of humus and also has a very good ability in mineral protecting [14]. Then, sapric peat can be characterize as an incredibly powerful natural fertilizer, yet one which is extremely gentle to the soil. Decaying process that occurring in perfectly as a factor that sapric peat providing a lot of nutrients compared to hemic and fibric peat. Thus, the role of potassium as physiological processes can happen with effectively and helps plants live a healthy life. Beside the presence of potassium naturally, the use of fertilizers as an additive can affect the chemical reaction in sapric peat. Environmental factors affecting the concentration of potassium in sapric peat such as the presence of rainwater. However, the differential condition in the experiments such as wet and dry condition as a mechanism helps to process the data analysis. The objective of this study was to determine the concentration of potassium in sapric peat under different conditions.

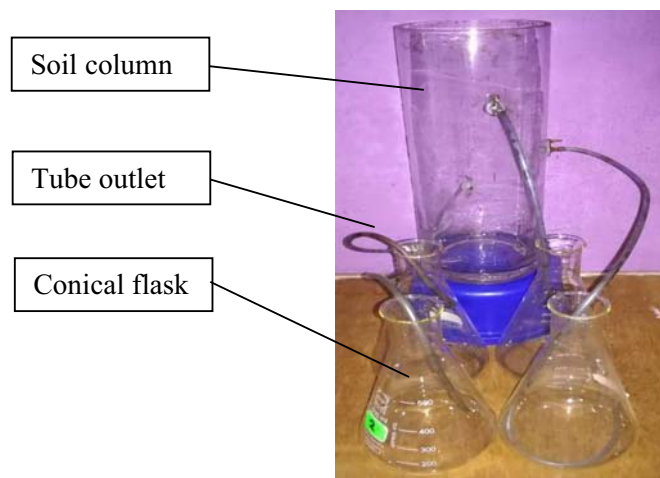
## 2. Materials and Methods

The sapric peat used for the study was collected from Kampung Medan Sari, Pontian, Johor, Malaysia (Figure 2.1). The samples were placed in bins and were covered with plastics bags to conserve the moisture content. The preparation of peat soil sample begins by separating the fiber greater than 1 cm from the container containing the peat. A study was conducted on the water that comes out of the soil column to determine the presence of soil nutrients. The detailed dimension of the soil column used for the investigation was 280 mm height and 110 mm diameter. The design of the soil column comprises of 4 outlets. The difference between the outlets was 70 mm from the top and bottom of the soil column. The soil column is illustrated in Figure 2.2.



**Figure 1.** Location of soil sample collection

The aim was to determine the concentration of metal ions that leach out based on the depth of the column. Soil samples were placed in the soil column by compacting the soil each time it was inserted into the column. 3000 ml of distilled water was used to flush the soil sample in order to clean the soil from fertilizer and heavy metals. The distilled water poured into the soil column was to leach out the fertilizer and heavy metals from the column. The process was followed by sapric and rainwater condition to identify the likely contaminants in the medium of soil and rain water in two different seasons where involving the dry and wet season. 100 ml was used to infiltrate the soil in the dry season while 1500 ml was used to saturate the soil in the wet season. The evaluation of the amount of water that is required for the retaining capacity of the soil was based on the seasonal conditions. For instance, 1500ml acts as a saturated condition based on volume of soil column and pore size. The comparison between volume of soil column and tabulation of rainfall was done according to the wet season. However, the reverse calculations was needed for dry season with comparison between volume of soil column and tabulation of rainfall by using 1500ml as a subject. Furthermore, the study also covers the actual situation used to illustrate the effect of sapric, rainwater and fertilizer condition on the agricultural area. Wet and dry seasons were also conducted to determine the concentration of potassium leached into the water. 0.1 mg of fertilizer was used for the investigation. The concentration of potassium was determined using the atomic absorption spectroscopy (AAS).

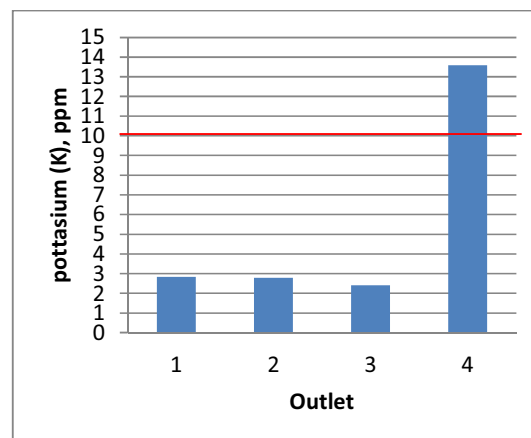


**Figure 2.** Soil column for water leaching

### 3. Results and Discussion

The investigation of the presence of potassium in the soil was demonstrated by the water leached at the outlet of the soil column. The result of the water leached at the outlets of the column showed the presence of potassium in the soil. Besides that, it can also be deduced that the presence of potassium could also probably be due to the source of the soil sample which was obtained from agricultural land. The intake of fertilizers as a source of nutrient was aimed to increase crop production. Potassium is present in the form of cation minerals required by plants for absorption [10]. The absorption of potassium occurs in the plant at quite a high concentration, in particular in the meristematic tissues and in the phloem [9].

According to the Environmental Quality Standards Regulations, 1999, water quality standard is divided into two, namely surface water standard and groundwater standard. This studies is more focused on groundwater quality and the standards were utilized as the reference point to determine the condition of the soil. The groundwater standard limit for potassium is usually less than 10 mg/l or 10.01 ppm. In this study, flush leachate in Figure 3 was observed to have high concentration of potassium was 13.58 ppm at outlet 4. This value was the highest compared to outlet 1, 2 and 3 having values of 2.837 ppm, 2.799 ppm and 2.401 ppm respectively. Also, the concentration of potassium at outlet 4 can be said to be high and more than the standard of groundwater. Although the outlet 3 was the lowest in terms of the potassium concentration. In the case of other outlets, the potassium concentration is almost identical for the outlet 1 and 2. Although sapric peat can be categorized as saturated peat when compared to other type, but the amount of nutrient retained is high in sapric peat compared to hemic and fibric peat. Then, the flow and storage of water that move through the peat are intimately related to the physical properties of peat making outlet 4 is high concentration. The higher of nutrient in sapric peat is due to the degree of decomposition and process of decaying [15]. Besides that, the high concentrations of potassium at outlet 4 could probably be due to sapric peat deposits which may likely exist at lower void ratio and could display lower permeability, lower compressibility, lower frictional angle and at a higher coefficient of earth pressure at rest [5]. This can be explained by the time factor and the distance taken by the water to move in the soil. For this reason, the presence of water helps potassium to combine together from the soil surface to the deepest area of the soil column. Based on the result, outlet 4 as a groundwater level can be said to be contaminated due to the concentration value exceeding the permissible standard. In addition, the value of potassium in sapric also was recorded as 21.617 ppm based on the total value for all outlet.



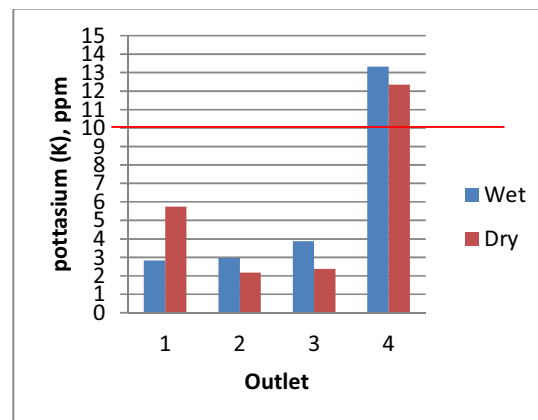
**Figure 3.** The reading of potassium under flush condition with combination of sapric and distilled water

Figure 4 illustrates the pattern nutrient yield for outlet 4 for sapric and rainwater condition. The result obtained showed that the potassium concentration was higher than the groundwater standard and was same as flush. Harter [16] stated that the allowable range for potassium as secondary constituents was 0.01 - 10 mg /l. From this investigation, the value of potassium in rainwater was evaluated as 0.21 ppm. The result obtained for sapric and rainwater experiment generally showed that outlet 4 recorded the highest value of potassium for both wet and dry condition compared to other outlets. However, wet condition was observed higher by 7.35% than dry condition. Soil wetting and drying also significantly affects the potassium fixation in the soil [17]. Outlet 1 achieved the lowest value compared to other outlets and in comparison with the standard condition, the value achieved for potassium for wet condition was also low by 55.97 % compared to the dry condition. This phenomena can be attributed to the high volume of water leached out at outlet 1 which reduce the concentration of potassium in the soil. In addition, outlet 1 can be considered as soil surface and the amount of potassium present in the surface soil was low when it is related to the soil volume between the surface level and the outlet 1 level. In comparison, the highest value of 13.320 ppm was obtained for the wet condition with the outlet 4 followed by outlet 1, 2 and 3 with value of 2.825 ppm, 2.961 ppm and 3.971 ppm respectively.

The concentration of potassium at outlet 4 that exceeding the standard limit indicates the effect of groundwater quality may be occur. The factor that influenced the yield of potassium was similar as mentioned for the flush condition which were the time and distance taken by the water to move into the soil and affect the concentration of potassium. Total amount of potassium for all outlet generally is 23.007 ppm which exceeds the standard limit proving that sapric peat has a high nutrient.

For the dry condition, outlet 2 was lower than the other outlets and if compared according to seasonal conditions. Dry condition was observed to be low compared to the wet condition with difference of 26.55%. Besides that, the concentration of potassium for outlet 4 was the highest with value of 12.340 ppm. Although Rahman [18] stated, sapric peat has more than 90 % of finer particles which make it difficult for assist in the permeability and movement of water, the potassium is still able to dissolve in water and increase concentration. Metal will move underground naturally and act in tandem with groundwater to produce contaminants [19]. The outlet 1 recorded the second highest value followed by the outlet 3 and 2 with value of 5.741, 2.175 and 2.375 respectively. However, the less difference of a concentration of potassium between outlet 2 and 3 was probably due to the arrangement of particles closer which made it difficult for the water to leach out from the soil column. Although the dry condition, the total concentration of potassium for all outlet is 22.631

ppm and can be consider exceeding the standard limit even without the presence of fertilizer. This proves that sapric peat has a high nutrient due to the complete decomposition process resulting in a high concentration of potassium even in dry condition.



**Figure 4.** The reading of potassium in sapric under rainwater condition

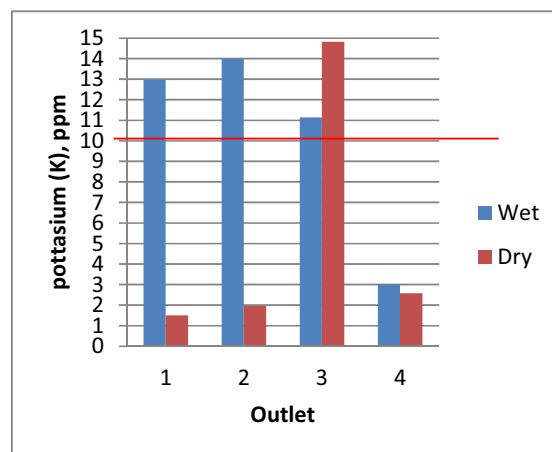
Generally, peat soils also requires input such as fertilizers and ameliorants to improve and maintain soil fertility [20]. Based on Figure 5, the result of sapric, rainwater and fertilizer condition showed that the outlets 1 and 2 can be said to be high level for wet condition where outlet 2 achieved the highest concentration with a reading of 13.990 ppm. This condition is contradictory with flush, sapric and rainwater condition where potassium was observed high at the outlet 4. The value for outlet 1 was obtained as 12.971 ppm followed by outlet 3 and 4 which were 11.141 ppm and 3.008 ppm respectively. The amount of metals at the soil surface is usually higher than the concentration at the bottom of the soil. Environmental factors such as agriculture, industrial and solid wastes and urban activities can also cause pollution at the same time concentration of metal at soil surface is high [21]. Besides that, this is attributed to the occurrence of low water solubility in very low mobility especially in cases prone to the accumulation in surface horizons of the soil [22]. The extent of leaching depends upon various factors which includes texture, amount of K applied, number and frequency of leaching either in terms of irrigation or rainfall event [23]. The impact of the high concentration of potassium in the soil will affect the groundwater quality to produce salinity which can have negative impact on plant growth [24]. According to Holthusen [25] the use of potassium through the application of mineral K fertilizer affects the soil structure and the ability to absorb the water. In addition, higher concentration of potassium in soil solution was due to an increase in micro shear resistance that may explain the change in water retention. So, when solid fertilizer is used on the soil surface, the water and fertilizer are combined and it is possible that the water can leach out at outlet 1,2 and 3 higher than the outlet 4. Besides, solid fertilizer requires time to fully dissolve over liquid fertilizer which can act together with water and flow to the groundwater. Liquid fertilizers are best suited for solute as they readily dissolve in irrigation water.

However, outlets 4 achieved the lowest value for wet condition compared to other outlets with difference of 14.3% higher than the dry condition. The vertical movement of the ground surface is accompanied by changes in water storage, the hydraulics, biogeochemistry and thermal properties [26]. The coefficient of water storage of sapric peat and its saturated hydraulic conductivity similarly decreases rapidly with depth in the soil where the water leach out is less so that it affects the potassium concentration [27]. Also, the highest value obtained shows that at outlet 2, the difference between wet condition and dry condition can be said to be bigger with the value of 85.95% higher than dry condition. Based on the total concentration of potassium for all outlet in wet condition is



41.11 ppm. High potassium values in sapric peat naturally and the use of fertilizers for agriculture causing potassium values are high in sapric peat and can effect groundwater quality.

Furthermore, for dry condition, outlet 3 was at highest position compared to the other outlets with reading of 14.820 ppm and a difference of 24.8% was observed higher for dry condition than wet condition. The pattern of the graph illustrated a bigger difference between the outlet 3 and other outlets followed by outlet 4, 2 and 1 with reading of 2.578 ppm, 1.965 ppm and 1.507 ppm respectively. Undecomposed peat near the ground surface has both elastic and plastic properties that enables it to expand and contract readily with wetting and drying conditions [27]. In terms of the observation, the concentration of potassium at outlet 1 and 2 were observed low. This trend may likely be due to the arrangement of its pores where during dry condition, the soil shrinks with evidence of reduction in pore sizes. The deposition of soil particles is also a likely factor that contributed to low concentration of potassium at the outlet 4. The arrangement of the soil particles on the outlet 4 is closer than the outlets 1,2 and 3, this is because the movement of the water is limited to the outlet 3 as represented by the base of the soil column. Hence water leaching out at outlet 1,2 and 3 causes the potassium levels to be too high. However, the total concentration of potassium for all outlet in dry condition is 20.87 ppm. When viewed as a whole for comparison between wet condition and dry condition, the concentration of potassium was observed always high for outlet 1, 2 and 4 for wet condition compared to outlet 3 which experienced high concentration of potassium in the dry condition.



**Figure 5.** The reading of potassium in sapric under rainwater and fertilizer condition

#### 4. Conclusion

The influence of environmental conditions on the concentration of potassium in the sapric peat has been investigated. The effect of soil nutrient showed that potassium in sapric was recorded as 21.617 ppm based on the total value for all outlets. This gives evidence that the use of chemical fertilizers can affect groundwater quality especially if it is used excessively. Thus, this experiment can serve as useful guide for farmers on the application of fertilizers for crops.

#### Acknowledgment

The authors would like thank you to University Tun Hussein Onn Malaysia, Faculty of Civil and Environmental Engineering (FKAAS), Office for Research, Innovation, Commercialization and Consultancy Management (ORICC) to make this study a success especially Centre For Graduate Studies because this paper was partly sponsored by the Centre for Graduate Studies UTHM.

## 5. Reference

- [1] Muhamad, I. S., Seca, G., Osumanu, H. A., & Nik, M. 2010. Comparison of selected chemical properties of peat swamp soil before and after timber harvesting. *American Journal of Environmental Sciences*, **6**(2), 164-167.
- [2] Reeza, A.A. & Hussin, A., 2014. Effect of liming and fertilizer application in hemic and sapric of tropical peat : phosphorus mineralization , infra-red spectroscopy and microscopy. , **9**(3), pp.321-333.
- [3] Adon, R., Bakar, I., Wijeyesekera, D. C., & Zainorabidin, A. 2013. Overview of the sustainable uses of peat soil in Malaysia with some relevant geotechnical assessments. *International Journal of Integrated Engineering*, **4**(4).
- [4] Jinming, H., & Xuehui, M. 2002. Physical and chemical properties of peat. Encyclopedia of life support systems: Coal, oil, shale, natural bitumen, heavy oil and peat, 2.
- [5] Kazemian, S., Huat, B. B., Prasad, A., & Barghchi, M. 2011. Effect of peat media on stabilization of peat by traditional binders. *International Journal of Physical Sciences*, **6**(3), 476-481.
- [6] Huat, B. B., Kazemian, S., Prasad, A., & Barghchi, M. 2011. State of an art review of peat: General perspective. *International Journal of Physical Sciences*, **6**(8), 1988-1996.
- [7] Lim, K. H., Lim, S. S., Parish, F., & Suharto, R. 2012. RSPO manual on best management practices (BMPs) for existing oil palm cultivation on peat. RSPO, Kuala Lumpur.
- [8] Zhao, J., Ni, T., Li, J., Lu, Q., Fang, Z., Huang, Q., and Shen, Q. 2016. Effects of organic–inorganic compound fertilizer with reduced chemical fertilizer application on crop yields, soil biological activity and bacterial community structure in a rice–wheat cropping system. *Applied soil ecology*, **99**, 1-12
- [9] Zaman, S., Pramanick, P., & Mitra, A. Chemical fertilizer.
- [10] Zhang, X., Dong, W., Dai, X., Schaeffer, S., Yang, F., Radosevich, M., and Sun, X. 2015. Responses of absolute and specific soil enzyme activities to long term additions of organic and mineral fertilizer. *Science of the Total Environment*, **536**, 59-67.
- [11] Gendy, A. G., El Gohary, A. E., Omer, E. A., Hendawy, S. F., Hussein, M. S., Petrova, V., & Stancheva, I. 2015. Effect of nitrogen and potassium fertilizer on herbage and oil yield of chervil plant (*Anthriscuscerefolium* L.). *Industrial Crops and Products*, **69**, 167-174.
- [12] Sparks, D. L. 2001. Dynamics of K in soils and their role in management of K nutrition. International Potash Institute PR II K in nutrient management for sustainable crop production in India, New Delhi, India, 305.
- [13] Zörb, C., Senbayram, M., & Peiter, E. 2014. Potassium in agriculture–status and perspectives. *Journal of plant physiology*, **171**(9), 656-669.
- [14] Saharjo, B. H., & Nurhayati, A. D. 2005. Changes in chemical and physical properties of hemic peat under fire-based shifting cultivation. *Tropics*, **14**(3), 263-269.
- [15] Rezanezhad, F., Price, J. S., Quinton, W. L., Lennartz, B., Milojevic, T., & Van Cappellen, P. 2016. Structure of peat soils and implications for water storage, flow and solute transport: A review update for geochemists. *Chemical Geology*, **429**, 75-84.
- [16] Harter, T. 2003. Groundwater quality and groundwater pollution. UCANR Publications.
- [17] Blatt, M. R. 2016. Plant physiology: redefining the enigma of metabolism in stomatal movement. *Current Biology*, **26**(3), R107-R109.
- [18] Rahman, J.A. and Ming, C.C., 2015. Physico-Chemical Characterization of Peat at Different Decomposition Levels. , pp.4011–4019.
- [19] Wieben, C. M., Baker, R. J., & Nicholson, R. S. 2013. Nutrient concentrations in surface water and groundwater, and nitrate source identification using stable isotope analysis, in the Barnegat Bay-Little Egg Harbor watershed, New Jersey, 2010–11 (No. 2012-5287, pp. i-44). US Geological Survey.
- [20] Hikmatullah, 2014. Physical and Chemical Properties of Cultivated Peat Soils in Four Trial Sites



- of ICCTF in Kalimantan and Sumatra , Indonesia. Physical and Chemical Properties of Cultivated Peat Soils in Four Trial Sites of ICCTF in Kalimantan and Sumatra, Indonesia, **19**(3), pp.131–141.
- [21] Ashraf, M. A., Maah, M. J., & Yusoff, I. 2014. Soil contamination, risk assessment and remediation. In Environmental Risk Assessment of Soil Contamination. InTech.
- [22] Adelekan, B. A., & Abegunde, K. D. 2011. Heavy metals contamination of soil and groundwater at automobile mechanic villages in Ibadan, Nigeria. International journal of physical sciences, **6**(5), 1045-1058.
- [23] Sharma, V., & Sharma, K. N. 2013. Influence of accompanying anions on potassium retention and leaching in potato growing alluvial soils. Pedosphere, **23**(4), 464-471.
- [24] Jouyban, Z. 2012. The effects of salt stress on plant growth. *Tech J Engin & App Sci*, **2**(1), 7-10.
- [25] Holthusen, D., Peth, S., & Horn, R. 2010. Impact of potassium concentration and matric potential on soil stability derived from rheological parameters. *Soil and Tillage Research*, **111**(1), 75-85.
- [26] Waddington, J. M., Kellner, E., Strack, M., & Price, J. S. 2010. Differential peat deformation, compressibility, and water storage between peatland microforms: implications for ecosystem function and development. *Water Resources Research*, **46**(7).
- [27] Uchida, R. 2000. Essential nutrients for plant growth: nutrient functions and deficiency symptoms. Plant nutrient management in Hawaii's soils, 31-55.