Comprehensive Mapping Analysis for Underground Water Resources Evaluation using Engineering Survey and GIS-Assessment in Northern Region of Sierra Leone-

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論 文 名　:　Comprehensive Mapping Analysis for Underground Water Resources Evaluation using Engineering Survey and GIS－Assessment in Northern Region of Sierra Leone－（工学測量および GIS を利用した地下水資源評価に対する統合マッピング解析－シエラレオネ北部地域のアセスメント）

区　　分　:　乙

論　文　内　容　の　要　旨

Groundwater is used for drinking water to support daily life in rural areas where surface water is inadequate. Particularly in West Africa, securing drinking water is an urgent matter with the increase in population. In Tonkolili and Pepel districts in northern region of Sierra Leone, majority of the population depend on groundwater for domestic and other purposes. The iron ore is mined from Tonkolili and the iron concentrate is stockpiled in Pepel for shipping. Even though there is high, potential of groundwater and many boreholes drilled in the areas by aid agencies, there is still a serious problem with adequate availability and quality of groundwater, because both the quantity and quality of water in the boreholes are not properly maintained and managed. This is evident from long queues of people scrambling for water at drilled wells and the high amount of water related diseases reported at health centers in the project areas. The identification of geological characteristics of groundwater resources beneath any given point in the landscape and quantitatively and qualitatively determining how much groundwater is available for different kinds of end uses without compromising the resources is the foundation. Therefore, it is necessary to carry out surveying and analysis of geological condition and water quantity in existing boreholes to present an effective determination method to control pumping and find a new drilling position.

The objectives of this research is to determine how the mining activity from Tonkolili to Pepel affect the underground water resources and the groundwater quality of those areas, which could be used as basis for future guide that might help government agencies and various stakeholders to properly manage the water resources. The research focused on the hydro geologic framework of the areas, especially how different combinations of geologic, topographic, and hydrologic conditions control the abundance, chemistry and movement of groundwater beneath different geologic terrains based on groundwater investigation of 75 boreholes from the two districts.

This dissertation consists of six chapters, which are heighted below:

Chapter 1 is the introduction to groundwater. This chapter outlines the reason for groundwater investigation and assessment; it justifies the objectives and scope of the research. This chapter also reviews previous work and methods of geographic information system (GIS) and engineering survey related to the investigation.

Chapter 2 describes a method of engineering survey and GIS fitting for field investigations of water resources. Engineering survey was used for field measurements and the survey points are processed using GIS to produce the topographic map, geological map and drainage system map. GPS data points collected from the field may also be used to establish ground control points for aerial triangulation in photogrammetry. Each of these methods plays an important role in groundwater investigation.

Chapter 3 describes groundwater system of the project area and hydrological formations with the definition of certain important terms used in groundwater. It also discusses the data collection methods like the earth resistivity survey, pumping test and groundwater quality analysis. Specific aquifer properties (e.g. hydraulic conductivity, transmissivity or water table levels) are also explained on national and regional scale because groundwater storage hinge on aquifer parameters, rate of water movement and recharge of the aquifers. The project areas revealed confine aquifer system. 1) Tonkolili district: granitic terrain with fracture aquifer system and 2) Pepel district: sediments with sand porous aquifer system.

Chapter 4 details the methodologies used in groundwater investigation and water quality analyses. The softwares, Zond Vesip for resistivity analysis, Aquifer Test Pro for pumping test and Arc Map for GIS, were used to model the aquifer depths, which range from 5 to16 m below surface level in Pepel depending on the elevation. The research involved 74 boreholes where 35 boreholes were drilled in the sedimentary sequence in Pepel and 39 in the fractured basement aquifer in Tonkolili. The resistivity values from Pepel were plotted to describe the sub-surface layers, and the pumping tests were done in all the boreholes. The geophysical survey results of the five boreholes revealed the presence of four lithological formations with groundwater being sourced from the third and fourth layers. However, the fourth layer consisting of sand/gravel is considered more prolific than the third layer. The apparent resistivity values form the sedimentary sequence range from low of 103Ωm to high of 11700Ωm. The transmissivity increases with decrease in resistivity through the layers. This has a tendency to find suitable place to drill a new borehole.

Chapter 5 discusses and analyzes the results. Whilst the granitic terrain comprises of fractured aquifer system and a clay layer (aquitard), the sediments comprises of sand aquifer system that exhibit high yield potential. Their analyses give a clear understanding of the aquifer system in the fracture basement with average borehole yield of 1.90m^3/hr. and that of the sedimentary sequence with average borehole yield potential of 2.04m^3/hr. The water quality test showed that pH values of 74% of boreholes in Tonkolili district and 54% of boreholes in Pepel districts were less than the WHO recommendation of 6.5-8.5. This shows that groundwater in those areas are mostly acidic. The study revealed that the turbidity of the sampled waters from 3 boreholes (7% of total) in Tonkolili were above the maximum concentration limits of 5 NTU recommended by WHO, while the waters sampled from 10 boreholes (29% of total) in Pepel were above the limit. The fecal coliforms were found in sampled water from 25% and 20% of the boreholes in Tonkolili and Pepel, respectively.

It was found that in Pepel, pH has a negative correlation with Fe^{2+} and Mn^{2+}. It implies that decrease in pH is related to increases in Fe^{2+} and Mn^{2+}, which results in increase of turbidity in both districts. The reason is that as the acid waters interact with the iron concentrate on the surface in Pepel and waste rocks of iron ore in Tonkolili, Fe^{2+} and Mn^{2+} are dissolved because of low pH. This may leach through the ground to contaminate the underground water resources. Fecal-coliform showed no correlation with pH in both districts. The presence of fecal coliforms in most of the wells may be due to movement of pollutants from closely located pit latrines and leaking septic tanks as well as indiscriminate defecation by people around the wells. The pH value has no relationship with transmissivity and resistivity.

Chapter 6 is a summary and conclusion of the findings and a recommendation for future studies on groundwater investigation and water quality analyses.