CAPILLARITY EFFECTS ON THE RADIONUCLIDE TRANSPORT

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ABSTRACT

Capillarity enables a dry soil to draw water to elevations above the phreatic line. In this study, radioisotope transport to the surface by the capillarity according to the changing of ground water level was investigated. Laboratory test method was developed to determine the capillary head effects on the radioisotope migration. During the laboratory tests, Cs-137 radionuclide solution was used as contaminated ground water, sand was used to maintain unsaturated (vadose) zone. Contaminated ground water was drawn up through the column by a piston. Initially, first part of the column was filled out by contaminated water to ensure the ground water bearing formation (saturated) at the near surface. Capillary head rise and saturation was recorded and sample was taken from these levels for analysing. Then, ground water level was changed periodically (hourly). At the each step, when the ground water go up to the saturation zone, sampling had been carried out from 10 levels and analysed to determine the bearing radioactivity. By this way, radioisotope migration caused by capillarity was examined and also vertical radionuclide migration caused by the changing of ground water level was determined. Degree of radioisotope migration was mostly depending on the degree of saturation according to the capillarity. Capillary head reached to its highest value after several cycles.

INTRODUCTION

Radioisotopes are transported by ground water according to the flow rate of ground water and other transport mechanisms. These transport mechanisms include; diffusion, dispersion and convection related to the conditions of media. Besides of the horizontal transport of the isotopes under the ground, another vertical transport mechanism will be effective by the increasing level of ground water.

Groundwater level is the equilibrium level of water pressure and the atmospheric pressure. In another words, this level is the border between the saturated zone and the unsaturated (vadose) zone. If the pores in the ground, below the groundwater table are entirely filled up with water, this area is called as the saturated zone. Above the groundwater table, pores are partly filled with water and this area is called as the unsaturated zone or vadose zone. From the surface of the earth to downward, vadose zone includes; the pendular zone, the funicular zone and the capillary zone. The pendular zone is the upper part of the vadose zone and its properties depend on the weather conditions (humudity, rainfall, temperature). At funicular zone, formation is mainly composed of capillary water and adsorbtive water.

Excess water flows downward due to the gravity. If the groundwater level is not deep enough, in that case funicular zone can be ignored because of its thickness. Finally, capillary zone exists at the lowest part of the vadose zone. The capillary zone filled up with water that drawn up from the saturated zone by the capillary action.

If the radioisotope reached and collected at the near surface by the ground water flow. At the final location, generally an aquifer exists near the surface. Water bearing formations near to the surface are commonly effected by increasing of groundwater level. Water in these formations starts to drawn up to the upper layers or go down according to the changes of ground water level. During these cycles, according to the saturation of the upper layers, concentration of the isotope was determined by using a simple laboratory equipment.

TEST METHOD

A column was developed to represent the increasing of the ground water level in the vadose zone. Diameter of the column is 10 cm and the height of the column is 160 cm. The column was designed with small holes for taking samples from several levels. It has a piston mechanism at the bottom surface. A sieve was located in the column to provide the bottom surface for the sand. Sand which has fine grains (d= 0.5 - 1.5 mm) was put in the column and it was located on the sieve. The height of this material is 120 cm. (Fig.1).

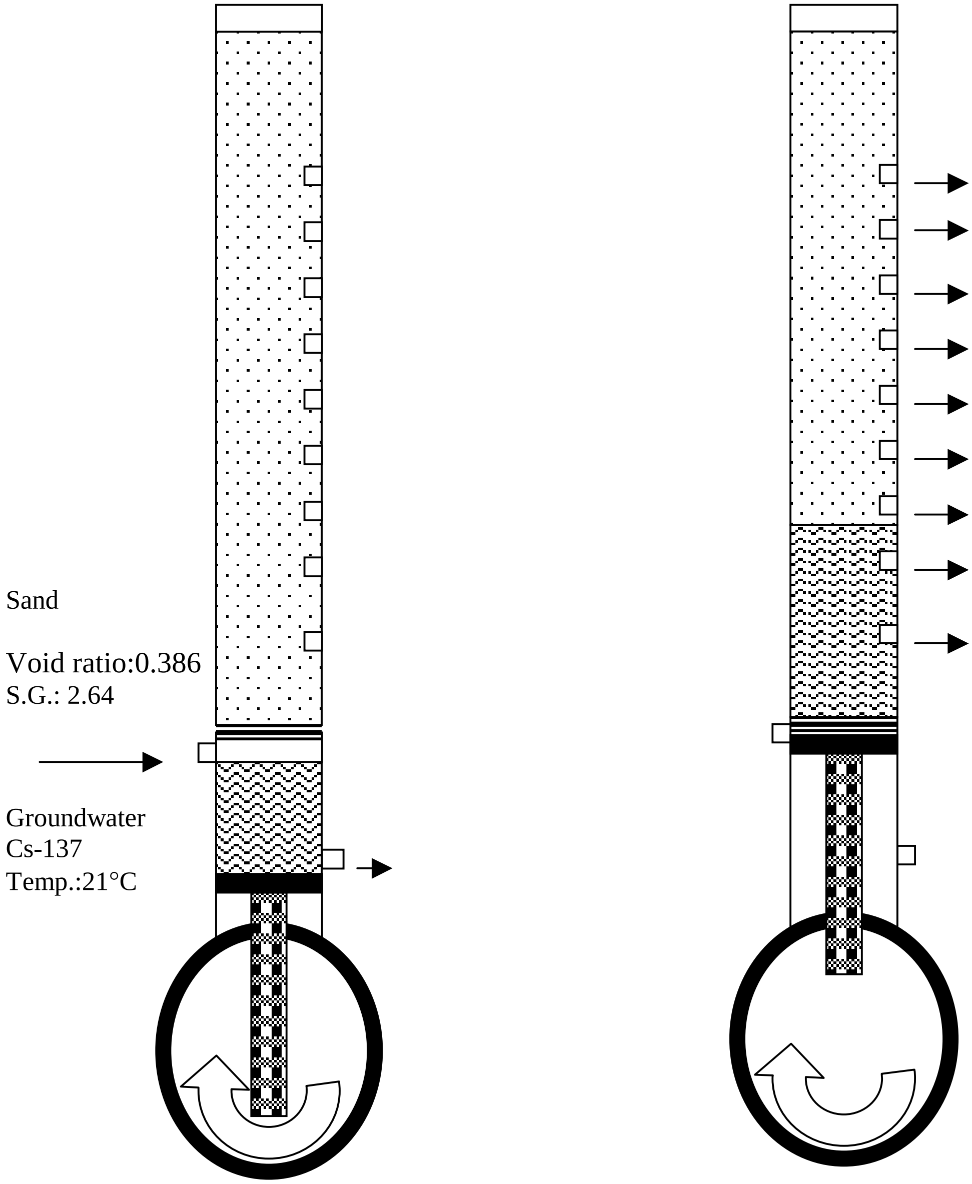

Fig. 1. Laboratory Test Equipment

RESULTS

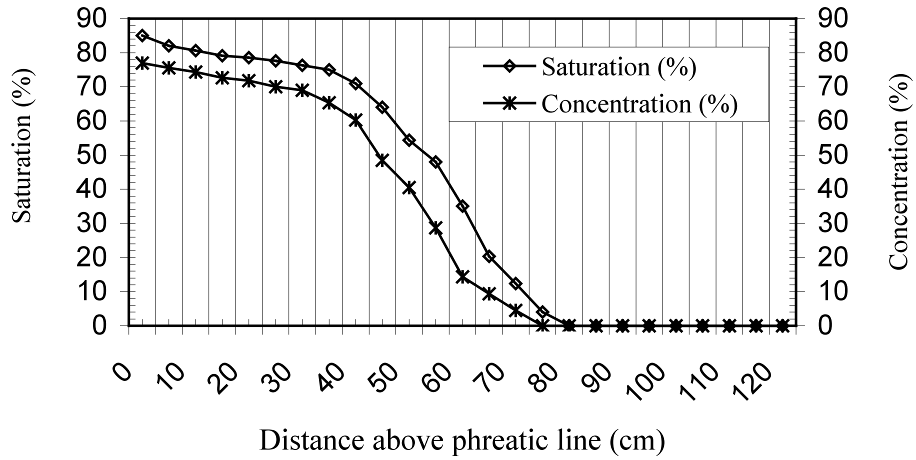

Fig. 2. Radioisotope saturation and concentration caused by capillarity effect.

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DISCUSSION

The movement of water into the dry sand by capillarity was not regular. Because the water travels more rapidly in the small pores, where the pulling force is stronger than in the large pores. Because of this unsteady drawn up, some of the pores are by-passed. Air remains in these pores. For this reason, at the first cycle, saturation level didn't reach to its maximum value. After the third cycle, saturation reached to its ultimate value.

The value of saturation capillary head increases as the void ratio of the sand is decreased. In another words, capillarity action is inversely proportional to the size of sand void at the air water interface. Degree of radioisotope migration was mostly depending on the degree of saturation according to the capillarity. Because of the absorption /grain diffusion at the lower parts of the column, radioactivity of the sample reduces due to the distance above the phreatic line.

Although the temperature of the water in the saturation capillary head test was measured, there is no significant change related to the temperature. Since, the capillary head depends directly on the surface tension of water, the capillary head decreases with an increase of the temperature.

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