# Simulation of Heat and Mass Transfer During Artificial Ground Freezing in Saturated Saline Groundwater

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**Introduction**: Artificial ground freezing (AGF) method, implemented in coastal areas, will inevitably face saline groundwater environment which will have an effect on the soil freezing process. The component diagram of freezing soil in saturated saline groundwater is shown in Figure 1.

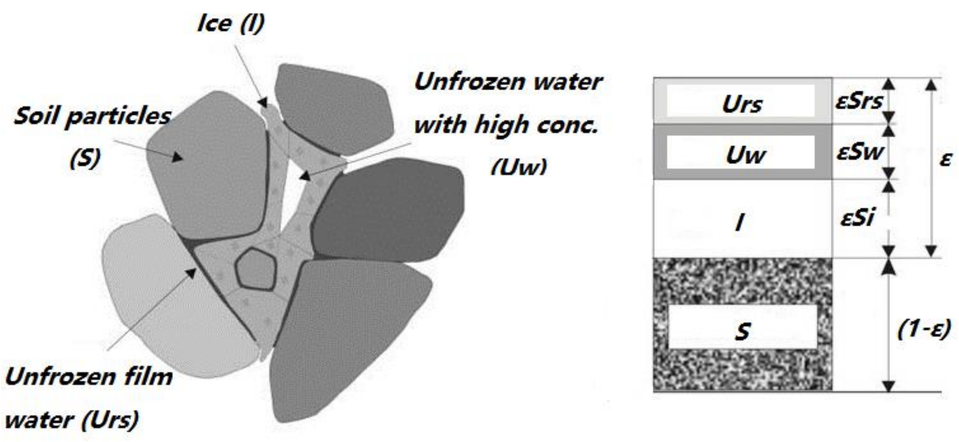


**Figure 1**. Component diagram of freezing soil in saturated saline groundwater

**Computational Methods**: Based on the theory of heat and mass transfer with phase change in porous media, soil freezing process in saturated saline groundwater will be presented by employing the conservation of mass for salt and the conservation of energy.

Solute diffusion equation and thermal conductivity equation for porous media are employed.

The presence of salt will have an effect on the freezing temperature (Figure 2). The curves of unfrozen water saturation and its derivative at c=600mol/m^3 are shown in Figure 3.

**Figure 2**. Freezing temperatures of various concentrations

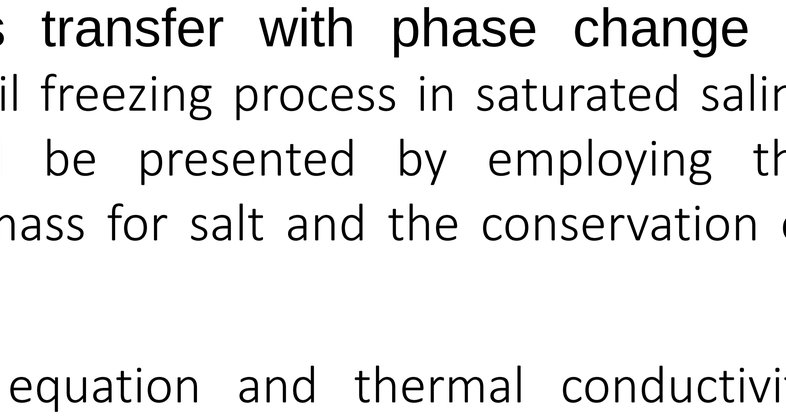


**Figure 3**. $S_w$ and its derivetive d(Sw,T) with respect to T curves at c=600mol/m$^3$

**Results**: A 2D soil freezing model consisted of multiple freezing pipes is simulated. The result of soil temperature and salinity at various ambient salinity on 40$^{th}$ day are shown in Figure 4.

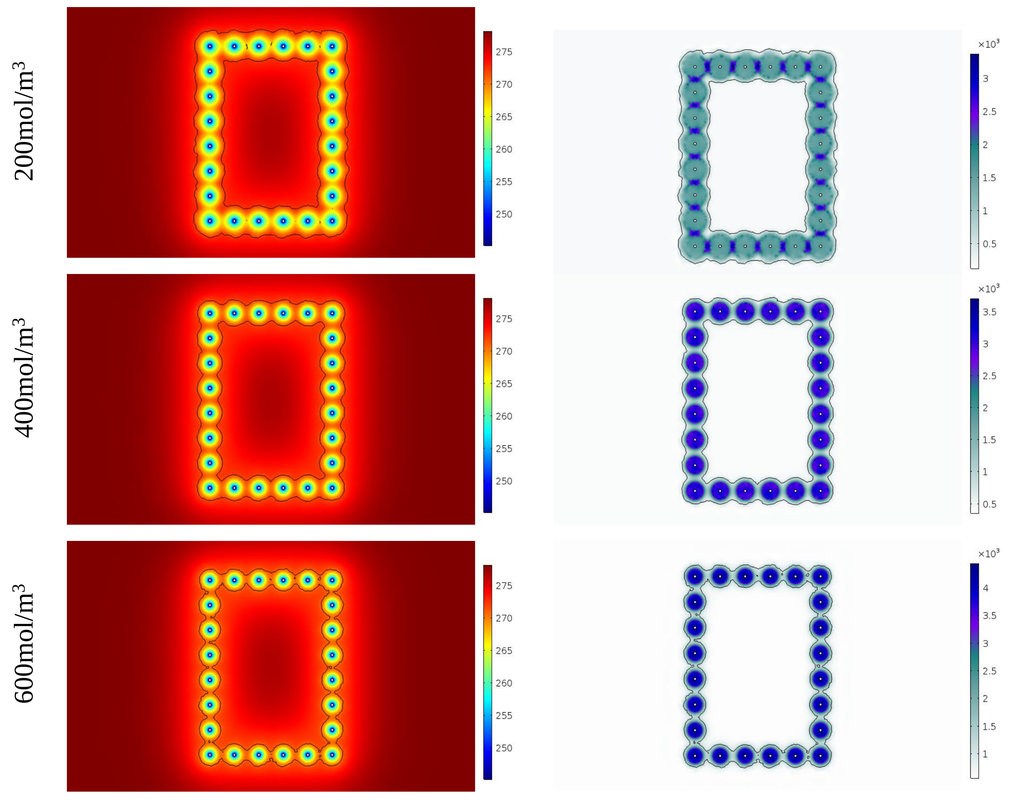


**Figure 4**.Ddistribution of soil temperature (left) and salinity (right) at various ambient salinity on the 40$^{th}$ day

**Conclusions**: The ambient salinity of groundwater will affect solute migration. The higher salinity is , the more obvious the inhibitory effect on the freezing barrier development can be observed (Figure 5).

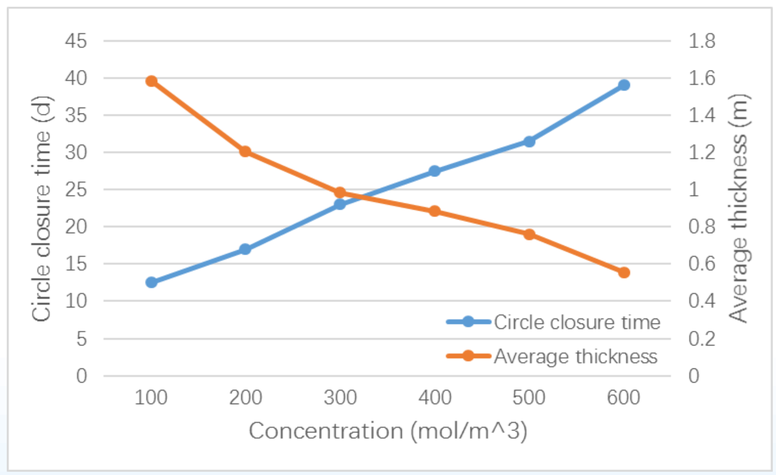


**Figure 5**. The changes of circle closure time of freezing barrier and average thickness of frozen barrier at various concentration.

## References:

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3. Hu R, Liu Q, Simulation of Heat Transfer during Artificial Ground Freezing Combined with Groundwater Flow, 2016 COMSOL conference in Munich.