A phenomenological material balance equation for the concentration of ions to be removed in water in water desalting devices.

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The material balance equation obtained in / 1 / for the averaged concentration of ions to be removed in water in a water desalting device contains the term proportional to the current density in the device. The sign of this current density is supposed to be matched with processes of regeneration and desalting in the device. However, for many cases of device operation, desalting and regeneration follow each other sometimes without change of the direction of the current. It makes inconsistent such supposition. The term proportional to the current density in this equation will have correct behavior if we suppose it to be proportional to

$$\mathrm{sign}(q(t))\ i(t), \qquad (1)$$

where $i(t)$ is the current density in the device, $i(t) = dq(t)/dt$, and $\mathrm{sign}(q)$ is the sign function that is determined by the condition that $\mathrm{sign}(q) = 1$ if $q > 0$ and $\mathrm{sign}(q) = -1$ if $q < 0$. We can come to this equation in the phenomenological approach assuming that balance of the ions in any column between the electrodes with unit area at the basis is connected with convection in a direction parallel to the electrodes and with the phenomenological source of the ions that is matched with processes charging-discharging of the electrodes. This phenomenological source must be proportional to the current density in the device but its sign must be determined by the sign of the term

$$(dq(t)/dt)\,/\,q(t), \qquad (2)$$

which is positive at charging and negative at discharging.
So, finally the phenomenological source of ions to be removed will be proportional to the expression (1). Because of mixing of different stream layers in the output purified water, the real dependence of the ion concentration on the coordinate perpendicular to the electrodes isn't essential. However, we should consider the convection velocity parameter in this equation as a phenomenological parameter to be matched with experimental results.

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References

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