calcium fluoride to a crystal having a sufficient size. Furthermore, a method for recovering fluoride ions in water using an aluminum salt (polyaluminum chloride or the like) has been known. However, the aluminum salt is very hardly separated from the water. In this case, it is necessary to use the aluminum salt and the polymeric flocculant in combination.

As described above, the fluorine recovering treatment in the water has a plurality of steps and is troublesome. Examples of the cause include difficult separation caused by a small particle diameter of the calcium fluoride to be produced, and difficult removal of the aluminum salt added into the water.

SUMMARY

An object of the present disclosure~~invention~~ is to provide a fluorine recovering apparatus and a method for recovering fluorine which can effectively remove fluorine in water by using a filter aid capable of removing particles of calcium fluoride or aluminum salt such as polyaluminum chloride which are hard to be separated.

In general, according to one embodiment, a fluorine~~fluonide~~ recovering apparatus includes a precipitating device, a mixing tank, a filter aid feeder, a solid-liquid separator, a cleaning mechanism, a separating tank, and a returning mechanism. The precipitating device is configured to allow fluoride ion-containing

water to be treated to react with calcium source and/or polyaluminum chloride to form fluorine-containing precipitate. The mixing tank is configured to mix a filter aid comprising particles of a magnetic material and having a primary particle diameter of 0.5 to 5 μm with a dispersion medium to produce slurry. The filter aid feeder is configured to feed the filter aid to the mixing tank. The solid-liquid separator is provided with a filter, and is configured to receive the slurry to deposit a layer made of the filter aid on the filter and to receive water containing precipitate to deposit the precipitate on the layer of the filter aid. The cleaning mechanism is configured to remove the filter aid and the precipitate from the solid-liquid separator. The separating tank is configured to separate the filter aid and the precipitate. The returning mechanism is configured to return the filter aid separated in the separating tank to the filter aid feeder.

In one aspect, there is provided a fluorine recovering apparatus, comprising: a precipitating device configured to allow fluoride ion-containing water to be treated to react with calcium source and/or polyaluminum chloride to form fluorine-containing precipitate; a mixing tank configured to mix a filter aid comprising particles of a magnetic material and having a primary particle diameter of 0.5 to 5 μm with a dispersion medium to produce slurry; a filter aid feeder configured to feed the filter aid to the mixing tank; a solid-liquid separator provided with a filter, the solid-liquid separator being configured to receive the slurry to deposit a layer made of the filter aid on the filter, and to receive water containing precipitate to deposit the precipitate on the layer of the filter aid; a cleaning mechanism configured to remove the filter aid and the precipitate from the solid-liquid separator; a separating tank configured to separate the filter aid and the precipitate; and a returning mechanism configured to return the filter aid separated in the separating tank to the filter aid feeder.

In another aspect, there is provided a fluorine recovering apparatus, comprising: a precipitating device configured to allow fluoride ion-containing water to be treated to react with calcium source and/or polyaluminum chloride to form fluorine-containing precipitate, and configure to mix a filter aid comprising particles of a magnetic material and having a primary particle diameter of 0.5 to 5 μm with water containing the fluorine-containing precipitate, to produce slurry; a filter aid feeder configured to feed the filter aid to the precipitating device; a solid-liquid separator provided with a filter, the solid-liquid separator being configured to receive the slurry to deposit the filter aid and the precipitate on the filter; a cleaning mechanism configured to remove the filter aid and the precipitate from the solid-liquid separator; a separating tank configured to separate the filter aid and the precipitate; and a returning mechanism configured to return the filter aid separated in the separating tank to the filter aid feeder.

In yet another aspect, there is provided a method for recovering fluorine, comprising: setting a first threshold value and a second threshold value lower than the first threshold value as two threshold values of a fluoride ion concentration in a fluoride ion-containing water to be treated; measuring the fluoride ion concentration in the water to be treated and determining whether the fluoride ion concentration is higher than the second threshold value; introducing the water to be treated to a precipitating device if the fluoride ion concentration is determined as equal to or higher than the second threshold value; measuring the fluoride ion concentration in the water to be treated introduced in the precipitating device; precipitating fluorine-containing precipitate in the precipitating device by reacting the water to be treated with a calcium source if the fluoride ion concentration is determined as equal to or higher than the first threshold value; precipitating fluorine-containing precipitate in the precipitating device by reacting the water to be treated with polyaluminum chloride if the fluoride ion concentration is determined as equal to or higher than the second threshold value and lower than the first threshold value; measuring the fluoride ion concentration in the water to be treated in the precipitating device and determining whether the fluoride ion concentration is lower than the second threshold value after the fluorine-containing precipitate is precipitated; mixing a filter aid comprising particles of a magnetic material and having a primary particle diameter of 0.5 to 5 μm with a dispersion medium to produce slurry; feeding the slurry to a solid-liquid separator provided with a filter to deposit a layer of the filter aid on the filter; introducing the water to be treated in the precipitating device to the solid-liquid separator thereby depositing the precipitate on the layer of the filter aid if the fluoride ion concentration in the water to be treated in the precipitating device is determined as lower than the second threshold value; removing the filter aid and the precipitate from the solid-liquid separator; separating the filter aid and the precipitate through magnetic separation; and reusing the separated filter aid.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view of a fluorine recovering apparatus according to example 1;

FIG. 2 is a schematic view of a fluorine recovering apparatus according to example 2;

FIG. 3 is a schematic view of a fluorine recovering apparatus according to example 5;

FIG. 4 is a schematic view of a fluorine