

A method of high-efficient resourcing of ammonia-nitrogen wastewater

5 [001] TECHNICAL FIELD

 [002] This invention relates to the technical field of wastewater treatment, and particularly relates to a method of high-efficient resourcing and utilization of a nitrogen-containing or ammonia-containing wastewater, especially an ammonia-nitrogen wastewater.

10 [003] BACKGROUND

 [004] Conventionally, ammonia nitrogen pollution will cause significant pollution to the ecological environment and render harms to human health. Large amount of ammonia-nitrogen wastewater is commonly produced from both the industrial wastewater and domestic sewage. The industrial ammonia-nitrogen wastewater is massively produced from petrochemical, metallurgical, pharmaceutical, fertilizer, electronics and other industries. In addition, ammonia-nitrogen wastewater would also be found in a secondary effluent from garbage treatment plants. Ammonia nitrogen is one of the main oxygen-consuming pollutants in water bodies. Therefore, eutrophication of the water body would generally be resulted in when an ammonia-nitrogen wastewater is directly discharged into the water bodies. The ammonia- nitrogen wastewater must be treated to reduce the concentration of ammonia- nitrogen before it can be discharged.

25 [005] At present, there are some common ammonia nitrogen removal methods, which comprise biological denitrification methods, gas or steam stripping methods, chemical precipitation methods, folding point chlorination methods, and supported gas membrane removal methods. Biological denitrification method is the most commonly used method, which mainly uses
30 microorganisms to convert nitrogen ions in the water into non-toxic or harmless

substances under anaerobic, anoxic or aerobic biochemical treatments.

However, the biological denitrification methods usually post high requirements on the quality of wastewater and are not suitable for denitrification treatments of

industrial wastewater that is usually presented in manners of with low organic
5 substance, high concentration in ammonia-nitrogen, high salinity or degrade-

resistant. Ammonia gas or steam stripping methods are simple, stable and
efficient, however usually consume huge energies also easily lead to secondary
pollutions, which requires frequent disassembling and cleaning of relevant
appliances, both leading to high cost of the process. Chemical precipitation

10 methods and folding point chlorination methods can effectively remove
ammonia nitrogen in wastewater but would introduce new compounds which
may cause secondary pollution and reduce the recoverability of wastewater.

Furthermore, although supported gas membrane removal methods can
significantly reduce the ammonia nitrogen concentration in wastewater, serious
15 penetration to the membrane is hardly overcome and are difficult to obtain high
quality expected byproducts for resourcing and recycling.

[006] Chinese patent application CN 101318752 A discloses a method
and device for reusing ammonia-nitrogen wastewater. The method comprising
the steps of adjusting the pH value of ammonia-nitrogen wastewater in an
20 automatic dosing device by pre-heating the device; evenly distributing water
through a removal section spray device and collecting the liquid at the bottom
liquid storage area; forcing air blowing to strip the ammonia-nitrogen repeatedly
in a circulating spray system before discharging the effluent; the ammonia-
containing waste gas is filtered by a demisting device and is subsequently
25 absorbed to form ammonia water through multiple-stage spraying process. This
method mainly adopts gas stripping and spraying operations, which does not use
a combination of multiple processes, and the removal efficiency of ammonia
nitrogen in wastewater is low and the diversity of ammonia-nitrogen wastewater
suitable for such treatment method are also limited.

[007] Chinese patent application CN 108706672 A discloses a resource utilization method of ammonia-nitrogen wastewater which comprises the following steps: adjusting the pH of an ammonia-nitrogen wastewater to 10 to 12, using a deamination membrane to degas and then absorb the ammonia-nitrogen through an acid liquid to obtain a deaminated wastewater and ammonia salt solution; air is then blown into the ammonia salt solution to strip the ammonia-nitrogen and to obtain a first stripped residual liquid I and a first ammonia-containing mixed gas I; the first ammonia-containing mixed gas I is absorbed by an absorbing liquid to obtain ammonia water; air is subsequently blown into the said ammonia water for stripping to obtain a second stripped residual liquid II and a second ammonia-containing mixed gas II; the second ammonia-containing mixed gas II is then absorbed by the ammonia water obtained in the previous step to obtain high quality ammonia water. This method only uses a deamination membrane to degas and absorb the ammonia-nitrogen wastewater and the subsequent treatment is to process the absorbed salt solution after the ammonia absorption, which is equivalent to one-time deamination treatment of the initial wastewater. As there is not combined deamination, the ammonia nitrogen removal efficiency is low and is also affected by the diversity of the ammonia-nitrogen wastewater.

[008] Chinese patent application CN 114477558 A discloses a method of deamination treatment of ammonia-nitrogen wastewater. This method comprises the following steps: adjust the pH of the ammonia-nitrogen wastewater and then perform air stripping to obtain a primary ammonia-nitrogen wastewater; stream stripping the primary ammonia-nitrogen wastewater to obtain a secondary ammonia-nitrogen wastewater; perform osmotic deamination to the secondary ammonia-nitrogen wastewater to obtain treated ammonia-nitrogen wastewater. The processes of air stripping, stream stripping and osmotic deamination are combined in sequence, and the ammonia nitrogen in the wastewater can be separated and removed in different conditions and concentrations, which leads

to a higher ammonia nitrogen removal efficiency. However, this method is performed under atmospheric condition, which is time-consuming. Furthermore, the energy consumption per unit wastewater in this method is also relatively high and the ammonia nitrogen in wastewater cannot be completely recycled.

5 [009] For high-efficiently recycling the ammonia-nitrogen wastewater, it is still required to further develop appropriate combination processes to recycle the ammonia nitrogen based on various concentrations and contents in the wastewater, to reduce the overall treatment cost and to lift the total ammonia nitrogen removal efficiency.

10 [010] DETAILED DESCRIPTION

[011] The following detailed description is merely illustrative in nature and is not intended to limit the embodiments of the subject matter of the application or uses of such embodiments.

15 [012] As used herein, the word “exemplary” means “serving as an example, instance, or illustration.” Any implementation described herein as exemplary is not necessarily to be construed as preferred or advantageous over other implementations. Furthermore, there is no intention to be bound by any expressed or implied theory presented in the preceding technical field,
20 background, brief summary or the following detailed description.

[013] This specification includes references to “one embodiment” or “an embodiment”. The appearances of the phrases “in one embodiment” or “in an embodiment” do not necessarily refer to the same embodiment. Particular features, structures, or characteristics may be combined in any suitable manner
25 consistent with this disclosure.

[014] Terminology. The following paragraphs provide definitions and/or context for terms found in this disclosure (including the appended claims):

[015] “Comprising”. This term is open-ended. As used in the appended claims, this term does not foreclose additional structure or steps.

[016] “First”, Second,” etc. As used herein, these terms are used as labels for nouns that they precede, and do not imply any type of ordering (e.g. spatial, temporal, logical, etc.). For example, reference to a “first” absorption liquid does not necessarily imply that this absorption liquid is the first absorption liquid in a sequence; instead, the term “first” is used to differentiate this absorption liquid from another absorption liquid (e.g., a “second” absorption liquid).

[017] “Based on”. As used herein, this term is used to describe one or more factors that affect a determination. This term does not foreclose additional factors that may affect a determination. That is, a determination may be solely based on those factors or based, at least in part, on those factors. Consider the phrase “determine A based on B.” While B may be a factor that affects the determination of A, such a phrase does not foreclose the determination of A from also being based on C. In other instances, A may be determined based solely on B.

[018] In addition, certain terminology may also be used in the following description for the purpose of reference only, and thus are not intended to be limiting. For example, terms such as “upper”, “lower”, “above”, and “below” refer to directions in the values in a range or ranges to which reference is made.

[019] Such terminology may include the words specifically mentioned above, derivatives thereof, and words of similar import. In the following description, numerous specific details are set forth, such as specific operations, in order to provide a thorough understanding of embodiments of the present disclosure. It will be apparent to one skilled in the art that embodiments of the present disclosure may be practiced without these specific details. In other instances, well-known techniques are not described in detail in order to not unnecessarily obscure embodiments of the present disclosure.

[020] In view of the problems existed in the prior art, the object of the present invention is to provide a method of high-efficient resourcing and utilization of an ammonia-nitrogen wastewater.

[021] The method uses a combined process to perform deamination treatment according to the composition and concentration of the ammonia-nitrogen wastewater, and completely reutilizes the ammonia-nitrogen substances existed in the said wastewater. The method adopts a combined processes to carry out deamination treatment of ammonia-nitrogen wastewater under different pressure conditions based on the composition and concentration of ammonia, achieving a higher total ammonia-nitrogen removal efficiency. Meanwhile, the method uses energy recycling arrangements comprising feeding the reaction heat released in a back-extraction process for heating the air for the air stripping and providing the reaction heat and dissolution heat released in the process of absorbing ammonia for heating the secondary ammonia-nitrogen wastewater for osmotic deamination.

[022] In order to achieve this goal, the present invention adopts the following technical solutions.

[023] On a first aspect, the present invention provides a method of resourcing an ammonia-nitrogen wastewater, the method comprising the following steps:

[024] (1) air stripping ammonia-nitrogen after adjusting a pH value of the ammonia-nitrogen wastewater to a range between 10 and 14, the temperature of the air stripping is between 20 °C and 50 °C, the stripped ammonia-nitrogen is absorbed by a first absorption liquid to obtain a product of ammonia-water while the residual liquid after the air stripping forms a primary ammonia-nitrogen wastewater, characterized in that the air for the air stripping is provided by a circulating compressor capable of providing an pressurized air, and the operating pressure of the air stripping is in a range from 0.11 MPa to 0.2 MPa;

[025] (2) extracting ammonia-nitrogen from the primary ammonia-nitrogen wastewater with an extraction agent comprising 2-ethylhexyl phosphate 2-ethylhexyl ester, alternatively named as Mono-2-ethylhexyl (2-Ethylhexyl)phosphonate or called as P507 in the art, the obtained extracted liquid is back-extracted by the ammonia-nitrogen wastewater and returned to step (1) as part of the ammonia-nitrogen wastewater to be treated while the residual liquid after extraction forms a secondary ammonia-nitrogen wastewater, characterized in that the reaction heat released by the back-extraction is fed back to step (1) for heating the air for the air stripping;

[026] (3) conducting osmotic deamination on the secondary ammonia-nitrogen wastewater with a pervaporation membrane, the ammonia-nitrogen molecule penetrates from one side of the pervaporation membrane to the other side during the osmotic deamination and is absorbed by a second absorption liquid to maintain a pressure difference of the pervaporation membrane, the absorbed second absorption liquid is returned to step (1) as part of the ammonia-nitrogen wastewater to be treated while the residual liquid after the osmotic deamination forms a treated ammonia-nitrogen wastewater, characterized in that the reaction heat and dissolution heat released in the process of absorbing ammonia-nitrogen by the second absorption liquid are used to heat the secondary ammonia-nitrogen wastewater for osmotic deamination, the pressure difference of the pervaporation membrane is in a range between 0.1Mpa and 0.5Mpa, the total ammonia-nitrogen removal efficiency reaches 99.95% and above, the removed ammonia-nitrogen is completely converted into the product of ammonia-water.

[027] For high efficiently recycling and realization of an ammonia-nitrogen wastewater, particularly for a wastewater having high or extreme high ammonia nitrogen concentration, a method with a single process treatment is hardly to fully remove the contained ammonia nitrogen, and thus a combined process is usually pursued. In the present invention, based on to the composition

and concentration of the ammonia-nitrogen wastewater, Appropriate treatment procedures, combination sequence and operation conditions are carefully selected and designed.

[028] The combined process of treatment methods comprises a step to
5 adjust the wastewater to a pH value that is suitable for ammonia-nitrogen removal by air stripping, and to apply an increased pressure inside the stripping equipment so as to reduce the solubility of ammonia is then performed. As the initial ammonia nitrogen concentration in the wastewater is high, air stripping is first used to remove majority of the ammonia nitrogen. As the processing time is
10 shorted under increased pressure, the corrosion to the reaction chamber is thus suppressed which reduce the mandatory maintenance frequency. Subsequently, a deamination procedure of extraction under atmospheric pressure or reduced pressure is conducted by using an extraction agent comprising 2-secondary hexyl phosphate mono-2-secondary hexyl ester to further reduce the
15 concentration of ammonia nitrogen in the wastewater. Finally, the extracted residue liquid is treated by pervaporation membrane to further remove the ammonia nitrogen. For reaching the above procedure combinations, combination sequences and the respective operation conditions, the inventor has conducted massive optimization experiments and completed large number of
20 analysis and finalization, and the optimal ammonia nitrogen concentration range and the combinations of treatment procedures suitable for each selected process are determined while a complete reutilization of ammonia nitrogen in the wastewater is unexpected achieved. Notably, the operations of each process are very simple and the cost per unit is low. The total nitrogen removal efficiency is
25 high, the contained ammonia nitrogen components can be fully restored for direct use. The method also shows a large processing capacity and is suitable for treating various types of ammonia-nitrogen wastewater, which does not cause any secondary pollution. The method furthermore effectively recovers and

utilizes the heat generated during the treating processes, achieving complete resource utilization of ammonia-nitrogen wastewater.

[029] The following technical solutions are preferred technical solutions of the present invention and do not limit the scope of the technical solutions provided by the gist of the present invention. Through the following technical solutions, the technical objectives and technical effects of the present invention can be better achieved and realized.

[030] Preferably, the source of the ammonia-nitrogen wastewater to be treated in step (1) comprises at least one from the group consisting of a landfill leachate filtrate, an absorption liquid of an ammonia-containing waste gas or an ammonia-containing waste liquid produced by smelting. Typical but non-limiting examples of the above combinations includes a combination of garbage filtrate and an absorption liquid of an ammonia-containing waste gas, a combination of an absorption liquid of an ammonia-containing waste gas and an ammonia-containing waste liquid produced by smelting, a combination of garbage filtrate, an absorption liquid of an ammonia-containing waste gas and an ammonia-containing waste liquid produced by smelting, etc.

[031] Preferably, the ammonia nitrogen concentration in the initial ammonia-nitrogen wastewater to be treated in step (1) is in a range from 10 g/L to 100 g/L, such as 10 g/L, 30 g/L, 50 g/L, 60 g/L, 80 g/L or 100 g/L, etc., and is not limited to the specified values, other unspecified values within the value range are also applicable.

[032] Preferably, the composition of the ammonia-nitrogen wastewater to be treated in step (1) comprising any one of ammonium sulfate, ammonium hydroxide or ammonium chloride, or any combinations thereof. Typical but non-limiting examples of the combination are: ammonium sulfate and ammonium carbonate; ammonium carbonate and ammonium chloride; ammonium sulfate, ammonium carbonate and ammonium chloride, etc.

[033] Preferably, the pH values that the ammonia-nitrogen wastewater adjusted to in step (1) is in a range between 10 and 14, such as 10, 10.5, 11, 11.5, 12, 12.5, 13, 13.5 or 14, etc., and is not limited to the specified values, other unspecified values within the value range are also applicable. In the present invention, the purpose of adjusting the pH value of the ammonia-nitrogen wastewater before treatment is to enable ammonia nitrogen to exist mainly in the form of NH_3 that could lead to the removal of NH_3 subsequently.

[034] Preferably, the air stripping demoulding in step (1) is conducted by blowing air for circulation within the reaction chamber of the treating equipment or any equivalences.

[035] Preferably, the temperature for the air stripping of step (1) is conducted in a range of 20 °C to 50 °C, such as 20°C, 25°C, 30°C, 35°C, 40°C, 45°C or 50°C, and is not limited to the specified values, other unspecified values within the value range are also applicable.

[036] Preferably, the air stripping in step (1) can be performed under increased pressure, and preferably with heating conditions as addressed above, and the operating pressure could be in the range of 0.11 MPa to 0.2 MPa, such as 0.11MPa, 0.12MPa, 0.13MPa, 0.15MPa, 0.18MPa, 0.2MPa, etc. and is not limited to the specified values, other unspecified values within the value range are also applicable. Alternatively, the operating pressure could be also conducted in the atmospheric pressure at around 0.1 MPa.

[037] Preferably, the time for air circulation in the air stripping of step (1) is in a range between 0.5 h and 2 h, such as 0.5 h, 0.8 h, 1 h, 1.2 h, 1.5 h, 1.8 h or 2 h, etc., and is not limited to the specified values, other unspecified values within the value range are also applicable.

[038] Preferably, the reaction heat and dissolution heat released during the absorption of ammonia by the first absorbing liquid in step (1) can be fed and used to lift the temperatures of any portion of the processing, such as completely heat the air for the air stripping in step (1), or partially heat the air

for the air stripping in step (1) and at the same time partially heat the secondary ammonia-nitrogen wastewater for the osmotic deamination as described in step (3), more preferably, can be fed and used to heat the ammonia gas molecules at one side of the pervaporation membranes as described in step (3) to improve the absorption efficiency of the second absorption liquid for absorbing ammonia gas molecules.

[039] Preferably, the first absorption liquid used in step (1) is water, and more preferably, it is pure water, to obtain a product of ammonia-water. As a preferred technical solution of the present invention, low-concentration ammonia water containing a certain concentration of NH_3 can also be used as the first absorption liquid to obtain a product of ammonia-water. As another preferred technical solution of the present invention, the ammonia stripped out by air in step (1) is absorbed with any prescribed sulfuric acid, and a product of the ammonium sulfate could be recovered.

[040] Preferably, the ammonia-nitrogen concentration in the primary ammonia nitrogen of step (1) is in a range from 1 g/L to 5 g/L, such as 1 g/L, 1.5 g/L, 2 g/L, 2.5 g/L, 3 g/L, 3.5 g/L, 4 g/L, 4.5 g/L or 5 g/L, etc., and is not limited to the specified values, other unspecified values within the value range are also applicable.

[041] Preferably, 2-secondary hexyl phosphate mono-2-secondary hexyl ester as an extractant agent is used in the extractive denitrification, the extraction as described in step (2). Preferably, the extraction agent comprises 2-secondary hexyl phosphate mono-2-secondary hexyl ester and other extraction agents, wherein the mass ratio of 2-secondary hexyl phosphate mono-2-secondary hexyl ester in the entire extraction agent is 10-40%, and preferably, the mass ratio is 30 %.

[042] Preferably, the temperature for extraction operation in step (2) is at room temperature, such as in a range of 1°C to 40°C, preferably 10 °C to 38°C,

more preferably 15 °C to 35 °C, and is not limited to the specified values, other unspecified values within the value range are also applicable.

[043] Preferably, the extraction operation in step (2) can be performed under atmospheric pressure conditions, and the operating pressure is at about 0.1 MPa. Preferably, the extraction operation step (2) can also be performed under reduced pressure conditions. The operating pressure can be in a range of 0.05 MPa to 0.099 MPa, such as 0.05 MPa, 0.06 MPa, 0.07 MPa, 0.08 MPa, 0.09 MPa, etc., and is not limited to the specified values, other unspecified values within the value range are also applicable.

[044] Preferably, the time for extraction operation in step (2) is in a range of 0.1 h to 0.5 h, such as 0.1 h, 0.2 h, 0.25 h, 0.33 h, 0.4 h, 0.45 h or 0.5 h, etc., and is not limited to the specified values, other unspecified values within the value range are also applicable.

[045] Preferably, the extracted liquid obtained by the extraction operation would be subjected to a back-extraction process to restore the extraction agent. The back-extraction liquid can be at least one or any combinations of pure water, ammonia water or ammonia-nitrogen wastewater to be treated. More preferably, the initial ammonia-nitrogen wastewater to be treated is used for back-extraction to improve the efficiency and utilization of resources within the processing chain. After back-extraction and regeneration, the extracted liquid is then returned to step (1) and added to initial ammonia-nitrogen wastewater as part of the ammonia-nitrogen wastewater to be treated for the prescribed recycling treatments.

[046] Preferably, the reaction heat released by the back-extraction processing in step (2), either in whole or in part, is fed and provided to step (1) as the energy to heat air used for air stripping, or can be used as energy for heating the second ammonia-nitrogen wastewater in step (3), or can be fed and used to heat the ammonia gas molecules at one side of the pervaporation membranes as described in step (3) to improve the absorption efficiency of the

second absorption liquid for absorbing ammonia gas molecules. More preferably, the reaction heat released by the back-extraction process as described in step (2) is fed and provided to step (1) as the energy to heat air used for air stripping or the ammonia-nitrogen wastewater directly.

5 [047] Preferably, the ammonia-nitrogen concentration in the secondary ammonia nitrogen in step (2) is in a range from 200 ppm to 800 ppm, such as 200 ppm, 300 ppm, 400 ppm, 500 ppm, 600 ppm, 700 ppm or 800 ppm, etc., and is not limited to the specified values, other unspecified values within the value range are also applicable.

10 [048] Preferably, the osmotic deamination in step (3) is performed using a pervaporation membrane. During the osmotic deamination, ammonia ions permeate through the pervaporation membrane and enter the other side of the membrane, where they are absorbed by the second absorption liquid. The second absorption liquid is usually an acid liquid, preferably a sulfuric acid.

15 [049] Preferably, the temperature for the osmotic deamination in step (3) is in a range from 20 °C to 40 °C., such as 20 °C, 25 °C, 30 °C, 35 °C or 40 °C, etc., and is not limited to the specified values, other unspecified values within the value range are also applicable.

20 [050] Preferably, during the osmotic deamination process, the gaseous partial pressure difference between two sides of the pervaporation membrane of ammonia serves as the driving force for the permeation. Preferably, the osmotic deamination process in step (3) is carried out under atmospheric pressure or pressurized conditions, and the gaseous partial pressure difference of the pervaporation membrane during operation is 0.11 MPa to 0.5 MPa, such as 0.11
25 MPa, 0.15 MPa, 0.2 MPa, 0.25 MPa, 0.3 MPa, 0.35 MPa, 0.4 MPa or 0.5 MPa, etc., and is not limited to the specified values, other unspecified values within the value range are also applicable. Alternatively, the operating pressure could be also conducted in the atmospheric pressure at around 0.1 MPa. Thus, the gaseous partial pressure difference of the pervaporation membrane between two

sides of the pervaporation membrane of ammonia during the osmotic deamination operation can be from 0.1 MPa to 0.5 MPa.

[051] Preferably, the material of the pervaporation membrane used in step (3) could be selected from at least one and any one of ceramics, polyvinyl chloride (PVC) or polyvinyl alcohol (PVA), and the types of ceramics comprises aluminosilicate, boroaluminate and etc.

[052] Preferably, during the osmotic deamination process, ammonia molecules penetrate the pervaporation membrane and enter the other side and are absorbed by a second absorption liquid, preferably, the acid liquid, to maintain the differential pressure between the two sides of the pervaporation membrane, and the liquid molecules do not penetrate the pervaporation membrane.

[053] Preferably, the reaction heat and dissolution heat released during the absorption of ammonia gas by the second absorption liquid can be fed and used for the heating needs required in any portion of the processing chain. Particularly, the reaction heat and dissolution heat released during the absorption of ammonia gas by the second absorption liquid, either in whole or in part, can be fed and provide to step (1) as the energy to heat air used for air stripping, or can be used as energy for heating the second ammonia-nitrogen wastewater in step (3), or can be fed and used to heat the ammonia gas molecules at one side of the pervaporation membranes as described in step (3) to improve the absorption efficiency of the second absorption liquid for absorbing ammonia gas molecules. More preferably, the reaction heat and dissolution heat released during the absorption of ammonia gas by the second absorption liquid is used solely for heating the secondary ammonia-nitrogen wastewater in step (3).

[054] Preferably, the ammonia-nitrogen concentration in the treated ammonia nitrogen in step (3) is in a range of 15 ppm or below, such as 15 ppm, 12 ppm, 10 ppm, 8 ppm, 6 ppm, 4 ppm or 3 ppm, etc., and is not limited to the

specified values, other unspecified values within the value range are also applicable.

[055] In the present invention, the treated ammonia-nitrogen wastewater from step (3) basically does not contain ammonia ions or ammonium ions, and the cations are mainly sodium ions or potassium ions depends on the types of alkali used during the pH value adjustment operation, that is, step (3) could recycle ammonia nitrogen ions completely. Preferably, the ammonia-nitrogen concentration in the treated ammonia-nitrogen wastewater in step (3) is 15 ppm or below and the total ammonia-nitrogen removal efficiency after step (3) reaches 99.9%, respectively, more preferably, the ammonia-nitrogen concentration in the treated ammonia-nitrogen wastewater in step (3) is 8 ppm or below and the total ammonia-nitrogen removal efficiency after step (3) reaches 99.95%, respectively, and even more preferably, the ammonia-nitrogen concentration in the treated ammonia-nitrogen wastewater in step (3) is 3 ppm or below and the total ammonia-nitrogen removal efficiency after step (3) reaches 99.99%, respectively.

[056] Preferably, the composition of the treated ammonia-nitrogen wastewater in step (3) comprises at least one of sodium sulfate and sodium chloride.

[057] On a second aspect, the present invention provides, particularly, a method of resourcing an ammonia-nitrogen wastewater, the method comprising the following steps:

[058] (1) air stripping ammonia-nitrogen after adjusting a pH value of the ammonia-nitrogen wastewater to a range between 10 and 14, the ammonia nitrogen concentration in the ammonia-nitrogen wastewater is in a range from 10 g/L to 100 g/L, the temperature of the air stripping is between 20 °C and 50 °C, the time for air circulation in the air stripping is in a range between 0.5 h and 2 h, the stripped ammonia-nitrogen is absorbed by a first absorption liquid to obtain a product of ammonia-water while the residual liquid after the air

stripping forms a primary ammonia-nitrogen wastewater, characterized in that the composition of the ammonia-nitrogen wastewater comprising any one of ammonium sulfate, ammonium hydroxide or ammonium chloride or any combinations thereof, the operating pressure of the air stripping is in a range from 0.11 MPa to 0.2 MPa, the first absorption liquid is water, the ammonia-nitrogen concentration in the primary ammonia nitrogen is in a range from 1 g/L to 5 g/L;

[059] (2) extracting ammonia-nitrogen from the primary ammonia-nitrogen wastewater with an extraction agent comprising 2-ethylhexyl phosphate 2-ethylhexyl ester (P507), the obtained extracted liquid is back-extracted by the ammonia-nitrogen wastewater and returned to step (1) as part of the ammonia-nitrogen wastewater to be treated while the residual liquid after extraction forms a secondary ammonia-nitrogen wastewater, characterized in that the reaction heat released by the back-extraction is fed back to step (1) for heating the air for the air stripping, the mass ratio of 2-ethylhexyl phosphate 2-ethylhexyl ester in the extraction agent is preferably 30%, the ammonia-nitrogen concentration in the secondary ammonia nitrogen is in a range from 200 ppm to 800 ppm;

[060] (3) conducting osmotic deamination on the secondary ammonia-nitrogen wastewater with a pervaporation membrane, the ammonia-nitrogen molecule penetrates from one side of the pervaporation membrane to the other side during the osmotic deamination and is absorbed by a second absorption liquid to maintain a pressure difference of the pervaporation membrane, the temperature for the osmotic deamination is in a range from 20 °C to 40 °C, the absorbed second absorption liquid is returned to step (1) as part of the ammonia-nitrogen wastewater to be treated while the residual liquid after the osmotic deamination forms a treated ammonia-nitrogen wastewater, characterized in that the reaction heat and dissolution heat released in the process of absorbing ammonia-nitrogen by the second absorption liquid are

used to heat the secondary ammonia-nitrogen wastewater for osmotic deamination, the pressure difference of the gaseous partial pressure difference between two sides of the pervaporation membrane is in a range between 0.1 MPa and 0.5 MPa, the pervaporation membrane comprises any one of ceramics, polyvinyl chloride or polyvinyl alcohol, the second absorption liquid is acid liquid, preferably sulfuric acid, the ammonia-nitrogen concentration in the treated ammonia-nitrogen wastewater is 15 ppm or below and the total ammonia-nitrogen removal efficiency reaches 99.9% respectively, preferably, 8 ppm or below and 99.95% respectively, and more preferably, 3 ppm or below and 99.99% respectively.

[061] Compared with the prior art, the methods disclosed in the present invention has the following technical effects and benefits:

[062] (1) The methods of the present invention adopt a combined process to carry out denitrification treatments based on the composition and concentration of the ammonia-nitrogen in the wastewater to be treated. The combined process adopts the methods of air stripping, extraction denitrification and osmotic deamination sequentially, and these processes are effective under different pressure parameter conditions. The ammonia nitrogen in the wastewater can be treated appropriately at different concentrations, achieving a higher total ammonia-nitrogen removal efficiency and a higher conversion rate for regenerating a final product of ammonia water that has high-value economically. The total ammonia-nitrogen removal efficiency can reach up to more than 99.95%, achieving a thorough and complete resourcing and reutilization of the contained ammonia-nitrogen in the wastewater.

[063] (2) The methods of the present invention are simple to operate, have low cost, are suitable for treating various types of ammonia nitrogen wastewater. The methods also have a large processing capacity and do not cause secondary pollution. More importantly, the methods recycle fully the reaction heat and dissolution heat during the whole process and effectively reduce the

unit cost of resourcing the ammonia nitrogen wastewater by 5%-30% and reduce the process treatment time by 30%-50%.

[064] The present invention illustrates the detailed methods of the present invention through the above embodiments, but the present invention is not limited to the above detailed methods, that is, it does not mean that the present invention must rely on the above detailed methods to be implemented. Those skilled in the art should understand that any improvements to the present invention, related replacements of the methods of the present invention, addition of auxiliary method steps, selection of specific methods, etc., all fall within the scope of protection and disclosure of the present invention.

[065] BRIEF DESCRIPTION OF THE DRAWINGS

[066] Figure 1 is a process flow chart of the method of resourcing an ammonia-nitrogen wastewater of the present invention.

[067] EMBODIMENTS

[068] The technical solutions of the present invention will be further described in detail below, merely for facilitating a better understanding of the present invention. However, the following embodiments are only exemplary embodiments of the present invention and do not represent or limit the scope of protection of the present invention. The scope of protection of the present invention should be the same as the claims.

[069] Example 1:

[070] This embodiment provides a method of resourcing an ammonia-nitrogen wastewater, the efficient process flow chart of the method is shown in Figure 1 and the method comprising the following steps:

[071] (1) selecting an ammonia-nitrogen wastewater from a source of a landfill leachate to be treated, the ammonia nitrogen concentration in the

ammonia-nitrogen wastewater is 50 g/L, the composition of the ammonia-nitrogen wastewater comprises ammonium sulfate. Adjusting a pH value of the ammonia-nitrogen wastewater to 12. Under an operating pressure of 0.15 MPa, conducting an air stripping process on the ammonia-nitrogen wastewater at a temperature of 35 °C for 1 hour. Obtaining a product of ammonia-water by using pure water to absorb the ammonia and the residual liquid after the air stripping forms a primary ammonia-nitrogen wastewater, and the ammonia-nitrogen concentration in the primary ammonia nitrogen wastewater is 3 g/L.

[072] (2) extracting ammonia-nitrogen from the primary ammonia-nitrogen wastewater from step (1) with an extraction agent comprising 2-ethylhexyl phosphate 2-ethylhexyl ester (P507), the mass ratio of 2-ethylhexyl phosphate 2-ethylhexyl ester (P507) in the extraction agent is 30%. The extraction procedure is conducted under atmospheric pressure condition of around 0.10 MPa at room temperature of 25°C for the time of 0.3 hour.

Obtaining the residual liquid after extraction as a secondary ammonia-nitrogen wastewater whose ammonia-nitrogen concentration is 400 ppm. Meanwhile, the obtained extracted liquid is back-extracted by the ammonia-nitrogen wastewater and returned to step (1) as part of the ammonia-nitrogen wastewater to be treated for recycling. The reaction heat released by the back-extraction is fed back to step (1) for heating the air for the air stripping.

[073] (3) conducting osmotic deamination on the secondary ammonia-nitrogen wastewater with a pervaporation membrane at a temperature of is 30°C, and the pressure difference of the gaseous partial pressure difference between two sides of the pervaporation membrane is 0.3 MPa. The material of the pervaporation membrane is polyvinyl chloride. During the osmotic deamination, the ammonia-nitrogen molecule penetrates from one side of the pervaporation membrane to the other side and is absorbed by sulfuric acid liquid of to maintain the determined pressure difference of the pervaporation membrane. The reaction heat and dissolution heat released in the process of

absorbing ammonia-nitrogen by sulfuric acid are used to heat the secondary ammonia-nitrogen wastewater for osmotic deamination. The ammonia-nitrogen concentration in the treated ammonia-nitrogen wastewater is as low as 2 ppm.

[074] In this example, after the above combined treatment processes, the total ammonia-nitrogen removal efficiency reaches 99.99%. With a high deamination speed, the total treatment duration is reduced 40% as compared to conventional process. The unit cost of treating the ammonia-nitrogen wastewater is 30% lower than conventional methods and no secondary pollution is caused.

[075] Example 2

[076] This embodiment provides a method of resourcing an ammonia-nitrogen wastewater, the method comprising the following steps:

[077] (1) selecting an ammonia-nitrogen wastewater from a source of an absorption liquid of an ammonia-containing waste gas, the ammonia nitrogen concentration in the ammonia-nitrogen wastewater is 10 g/L, the composition of the ammonia-nitrogen wastewater comprises ammonium sulfate. Adjusting a pH value of the ammonia-nitrogen wastewater to 10. Under an operating pressure of 0.2 MPa, conducting an air stripping process on the ammonia-nitrogen wastewater at a temperature of 50 °C for 0.5 hour. Obtaining a product of ammonia-water by using an ammonia-water having 5% mass concentration of ammonia to absorb the ammonia. The residual liquid after the air stripping forms a primary ammonia-nitrogen wastewater, and the ammonia-nitrogen concentration in the primary ammonia nitrogen wastewater is 1 g/L.

[078] (2) extracting ammonia-nitrogen from the primary ammonia-nitrogen wastewater from step (1) with an extraction agent comprising 2-ethylhexyl phosphate 2-ethylhexyl ester (P507), the mass ratio of 2-ethylhexyl phosphate 2-ethylhexyl ester (P507) in the extraction agent is 25%. The extraction procedure is conducted under atmospheric pressure condition of

around 0.10 MPa at room temperature of 30°C for the time of 0.1 hour.

Obtaining the residual liquid after extraction as a secondary ammonia-nitrogen wastewater whose ammonia-nitrogen concentration is 200 ppm. Meanwhile, the obtained extracted liquid is back-extracted by an ammonia-containing

wastewater and returned to step (1) as part of the ammonia-nitrogen wastewater to be treated for recycling. The reaction heat released by the back-extraction is fed back to step (1) for heating the air for the air stripping.

[079] (3) conducting osmotic deamination on the secondary ammonia-nitrogen wastewater with a pervaporation membrane at a temperature of is 40°C, and the pressure difference of the gaseous partial pressure difference between two sides of the pervaporation membrane is 0.1 MPa. The material of the pervaporation membrane is polyvinyl alcohol. During the osmotic deamination, the ammonia-nitrogen molecule penetrates from one side of the pervaporation membrane to the other side and is absorbed by sulfuric acid liquid of to maintain the determined pressure difference of the pervaporation membrane. The reaction heat and dissolution heat released in the process of absorbing ammonia-nitrogen by sulfuric acid are used to heat the ammonia gas molecules at one side of the pervaporation membranes to improve the absorption efficiency of the sulfuric acid liquid for absorbing ammonia gas molecules. The ammonia-nitrogen concentration in the treated ammonia-nitrogen wastewater is as low as 3 ppm.

[080] In this example, after the above combined treatment processes, the total ammonia-nitrogen removal efficiency reaches 99.95%. With a high deamination speed, the total treatment duration is reduced 50% as compared to conventional process. The unit cost of treating the ammonia-nitrogen wastewater is 25% lower than conventional methods and no secondary pollution is caused.

[081] Example 3

[082] This embodiment provides a method of resourcing an ammonia-nitrogen wastewater, the method comprising the following steps:

[083] (1) selecting an ammonia-nitrogen wastewater from a source of an ammonia-containing waste liquid produced by smelting, the ammonia nitrogen concentration in the ammonia-nitrogen wastewater is 100 g/L, the composition of the ammonia-nitrogen wastewater comprises ammonium sulfate and ammonium chloride. Adjusting a pH value of the ammonia-nitrogen wastewater to 14. Under an operating pressure of 0.15 MPa, conducting an air stripping process on the ammonia-nitrogen wastewater at a temperature of 20 °C for 2 hour. Obtaining a product of ammonia-water by using an ammonia-water having 5% mass concentration of ammonia to absorb the ammonia. The residual liquid after the air stripping forms a primary ammonia-nitrogen wastewater, and the ammonia-nitrogen concentration in the primary ammonia nitrogen wastewater is 5 g/L.

[084] (2) extracting ammonia-nitrogen from the primary ammonia-nitrogen wastewater from step (1) with an extraction agent comprising 2-ethylhexyl phosphate 2-ethylhexyl ester (P507), the mass ratio of 2-ethylhexyl phosphate 2-ethylhexyl ester (P507) in the extraction agent is 35%. The extraction procedure is conducted under reduced pressure condition of around 0.08 MPa at the temperature of 5°C for the time of 1 hour. Obtaining the residual liquid after extraction as a secondary ammonia-nitrogen wastewater whose ammonia-nitrogen concentration is 600 ppm. Meanwhile, the obtained extracted liquid is back-extracted by an ammonia-containing wastewater and returned to step (1) as part of the ammonia-nitrogen wastewater to be treated for recycling. The reaction heat released by the back-extraction is fed back to step (1) for heating the air for the air stripping.

[085] (3) conducting osmotic deamination on the secondary ammonia-nitrogen wastewater with a pervaporation membrane at a temperature of is 20°C, and the pressure difference of the gaseous partial pressure difference

between two sides of the pervaporation membrane is 0.5 MPa. The material of the pervaporation membrane is aluminosilicate ceramics. During the osmotic deamination, the ammonia-nitrogen molecule penetrates from one side of the pervaporation membrane to the other side and is absorbed by sulfuric acid liquid
5 of to maintain the determined pressure difference of the pervaporation membrane. The reaction heat and dissolution heat released in the process of absorbing ammonia-nitrogen by sulfuric acid are used to heat the secondary ammonia-nitrogen wastewater for osmotic deamination. The ammonia-nitrogen concentration in the treated ammonia-nitrogen wastewater is as low as 3 ppm.

10 [086] In this example, after the above combined treatment processes, the total ammonia-nitrogen removal efficiency reaches 99.98%. With a high deamination speed, the total treatment duration is reduced 30% as compared to conventional process. The unit cost of treating the ammonia-nitrogen wastewater is 20% lower than conventional methods and no secondary pollution
15 is caused.

[087] Although specific embodiments have been described above, these embodiments are not intended to limit the scope of the present disclosure, even where only a single embodiment is described with respect to a particular
20 feature. Examples of features provided in the disclosure are intended to be illustrative rather than restrictive unless stated otherwise. The above description is intended to cover such alternatives, modifications, and equivalents as would be apparent to a person skilled in the art having the benefit of this disclosure. The scope of the present disclosure includes any feature or combination of
25 features disclosed herein (either explicitly or implicitly), or any generalization thereof, whether or not it mitigates any or all of the problems addressed herein.

[088] Accordingly, new claims may be formulated during prosecution of this application (or an application claiming priority thereto) to any such combination of features. In particular, with reference to the appended claims,

features from dependent claims may be combined with those of the independent claims and features from respective independent claims may be combined in any appropriate manner and not merely in the specific combinations enumerated in the appended claims.

Claims

1. A method of resourcing an ammonia-nitrogen wastewater, the method comprising the following steps:

(1) air stripping ammonia-nitrogen after adjusting a pH value of the ammonia-nitrogen wastewater to a range between 10 and 14, the temperature of the air stripping is between 20 °C and 50 °C, the stripped ammonia-nitrogen is absorbed by a first absorption liquid to obtain a product of ammonia-water while the residual liquid after the air stripping forms a primary ammonia-nitrogen wastewater,

characterized in that the air for the air stripping is provided by a circulating compressor capable of providing an pressurized air, and the operating pressure of the air stripping is in a range from 0.11 MPa to 0.2 MPa;

(2) extracting ammonia-nitrogen from the primary ammonia-nitrogen wastewater with an extraction agent comprising 2-ethylhexyl phosphate 2-ethylhexyl ester (P507), the obtained extracted liquid is back-extracted by the ammonia-nitrogen wastewater and returned to step (1) as part of the ammonia-nitrogen wastewater to be treated while the residual liquid after extraction forms a secondary ammonia-nitrogen wastewater,

characterized in that the reaction heat released by the back-extraction is fed back to step (1) for heating the air for the air stripping;

(3) conducting osmotic deamination on the secondary ammonia-nitrogen wastewater with a pervaporation membrane, the ammonia-nitrogen molecule penetrates from one side of the pervaporation membrane to the other side during the osmotic deamination and is absorbed by a second absorption liquid to maintain a pressure difference of the pervaporation membrane, the absorbed second absorption liquid is returned to step (1)

as part of the ammonia-nitrogen wastewater to be treated while the residual liquid after the osmotic deamination forms a treated ammonia-nitrogen wastewater,

characterized in that the reaction heat and dissolution heat released in the process of absorbing ammonia-nitrogen by the second absorption liquid are used to heat the secondary ammonia-nitrogen wastewater for osmotic deamination, the pressure difference of the gaseous partial pressure difference between two sides of the pervaporation membrane is in a range between 0.1Mpa and 0.5Mpa, the total ammonia-nitrogen removal efficiency reaches 99.95% and above, the removed ammonia-nitrogen is completely converted into the product of ammonia-water.

2. The method according to claim 1, characterized in that the source of the ammonia-nitrogen wastewater to be treated in step (1) comprises at least one from the group consisting of a landfill leachate filtrate, an absorption liquid of an ammonia-containing waste gas or an ammonia-containing waste liquid produced by smelting.

3. The method according to any one of claims 1 to 2, characterized in that the ammonia nitrogen concentration in the ammonia-nitrogen wastewater to be treated in step (1) is in a range from 10 g/L to 100 g/L.

4. The method according to any one of claims 1 to 3, characterized in that, the composition of the ammonia-nitrogen wastewater to be treated in step (1) comprising any one of ammonium sulfate, ammonium hydroxide or ammonium chloride, or any combinations thereof.

5. The method according to any one of claims 1 to 4, characterized in that, the time for air circulation in the air stripping of step (1) is in a range between 0.5 h and 2 h.

6. The method according to any one of claims 1 to 5, characterized in that the first absorption liquid in step (1) is water, preferably, pure water.
7. The method according to any one of claims 1 to 6, characterized in that the ammonia-nitrogen concentration in the primary ammonia nitrogen of step (1) is in a range from 1 g/L to 5 g/L.
8. The method according to any one of claims 1 to 7, characterized in that the time for extraction in step (2) is a range between 0.1 h and 0.5 h.
9. The method according to any one of claims 1 to 8, characterized in that the ammonia-nitrogen concentration in the secondary ammonia nitrogen in step (2) is in a range from 200 ppm to 800 ppm.
10. The method according to any one of claims 1 to 9, characterized in that the temperature for the osmotic deamination in step (3) is in a range from 20 °C to 40 °C.
11. The method according to any one of claims 1 to 10, characterized in that the second absorption liquid in step (3) is acid liquid, preferably sulfuric acid.
12. The method according to any one of claims 1 to 11, characterized in that the material of the pervaporation membrane in step (3) comprises any one of ceramics, polyvinyl chloride or polyvinyl alcohol.
13. The method according to any one of claims 1 to 12, characterized in that the ammonia-nitrogen concentration in the treated ammonia-nitrogen wastewater in step (3) is 15 ppm or below and the total ammonia-nitrogen removal efficiency after step (3) reaches 99.9% respectively, preferably, 8 ppm or below and 99.95% respectively, and more preferably, 3 ppm or below and 99.99% respectively.

14. The method according to any one of claims 1 to 13, characterized in that the composition of the treated ammonia-nitrogen wastewater in step (3) comprises at least one of sodium sulfate and sodium chloride.

15. A method of resourcing an ammonia-nitrogen wastewater, the method comprising the following steps:

(1) air stripping ammonia-nitrogen after adjusting a pH value of the ammonia-nitrogen wastewater to a range between 10 and 14, the ammonia nitrogen concentration in the ammonia-nitrogen wastewater is in a range from 10 g/L to 100 g/L, the temperature of the air stripping is between 20 °C and 50 °C, the time for air circulation in the air stripping is in a range between 0.5 h and 2 h, the stripped ammonia-nitrogen is absorbed by a first absorption liquid to obtain a product of ammonia-water while the residual liquid after the air stripping forms a primary ammonia-nitrogen wastewater,

characterized in that the composition of the ammonia-nitrogen wastewater comprising any one of ammonium sulfate, ammonium hydroxide or ammonium chloride or any combinations thereof, the operating pressure of the air stripping is in a range from 0.11 MPa to 0.2 MPa, the first absorption liquid is water, the ammonia-nitrogen concentration in the primary ammonia nitrogen is in a range from 1 g/L to 5 g/L;

(2) extracting ammonia-nitrogen from the primary ammonia-nitrogen wastewater with an extraction agent comprising 2-ethylhexyl phosphate 2-ethylhexyl ester (P507), the obtained extracted liquid is back-extracted by the ammonia-nitrogen wastewater and returned to step (1) as part of the ammonia-nitrogen wastewater to be treated while the residual liquid after extraction forms a secondary ammonia-nitrogen wastewater,

characterized in that the reaction heat released by the back-extraction is fed back to step (1) for heating the air for the air stripping, the mass ratio of 2-ethylhexyl phosphate 2-ethylhexyl ester in the extraction agent is preferably 30%, the ammonia-nitrogen concentration in the secondary ammonia nitrogen is in a range from 200 ppm to 800 ppm;

(3) conducting osmotic deamination on the secondary ammonia-nitrogen wastewater with a pervaporation membrane, the ammonia-nitrogen molecule penetrates from one side of the pervaporation membrane to the other side during the osmotic deamination and is absorbed by a second absorption liquid to maintain a pressure difference of the pervaporation membrane, the temperature for the osmotic deamination is in a range from 20 °C to 40 °C, the absorbed second absorption liquid is returned to step (1) as part of the ammonia-nitrogen wastewater to be treated while the residual liquid after the osmotic deamination forms a treated ammonia-nitrogen wastewater,

characterized in that the reaction heat and dissolution heat released in the process of absorbing ammonia-nitrogen by the second absorption liquid are used to heat the secondary ammonia-nitrogen wastewater for osmotic deamination, the pressure difference of the gaseous partial pressure difference between two sides of the pervaporation membrane is in a range between 0.1 MPa and 0.5 MPa, the pervaporation membrane comprises any one of ceramics, polyvinyl chloride or polyvinyl alcohol, the second absorption liquid is acid liquid, preferably sulfuric acid, the ammonia-nitrogen concentration in the treated ammonia-nitrogen wastewater is 15 ppm or below and the total ammonia-nitrogen removal efficiency reaches 99.9% respectively, preferably, 8 ppm or below and 99.95% respectively, and more preferably, 3 ppm or below and 99.99% respectively.