maintain a higher growth rate of the AOBs than that of the NOBs. With insufficient ammonium present, it is impossible to use sludge wasting (i.e. SRT Control) to out select the NOB but retain the AOB in the mainstream deammonification process.

Another problem that can be experienced in mainstream deammonification processes is that of sludge bulking. In bulking sludge, the mixed liquor suspended solids (MLSS) floc does not compact or settle well, and floc particles are discharged in the secondary clarifier effluent. Sludge bulking can occur in mainstream deammonification processes when the process is conducive to the growth and proliferation of filamentous organisms as opposed to non-filamentous organisms.

Therefore, there is a need for a mainstream deammonification process that addresses sludge bulking, controlling NOB growth, and providing for an adequate concentration of residual ammonium.

## SUMMARY

The present disclosure relates to a mainstream deammonification process for removing ammonium from wastewater that suppresses NOB growth and produces a sludge having good settling characteristics.

In an aspect, there is provided a mainstream deammonification process for removing ammonium from a wastewater stream, comprising:

clarifying the wastewater stream in a primary clarifier and producing a primary effluent;

directing a first portion of the primary effluent to a biological treatment reactor and removing carbon from the primary effluent to produce treated wastewater;

after treating the first portion of the primary effluent in the biological treatment reactor, directing the treated wastewater into an integrated fixed film activated sludge (IFAS) deammonification reactor that is provided with intermittent aeration including periods of air on and periods of air off;

directing a second portion of the primary effluent to the IFAS deammonification reactor and in the process bypassing the biological treatment reactor;

injecting the second portion of the primary effluent into the IFAS deammonification reactor during periods of air off and refraining from injecting the second portion of the primary effluent into the IFAS deammonification reactor during periods of air on, wherein the second portion of the primary effluent is mixed with the treated wastewater in the IFAS deammonification reactor to form a wastewater mixture;

in the IFAS deammonification reactor, removing ammonium from the wastewater mixture by a nitritation and anammox process; and

after removing ammonium from the wastewater mixture, directing the wastewater mixture to a secondary clarifier and producing a secondary effluent and a clarifier underflow, and recycling at least a portion of the underflow to the IFAS deammonification reactor.

In another aspect, there is provided a mainstream deammonification process for removing ammonium and phosphorus from a stream of wastewater while reducing the tendency of sludge produced in the process to bulk, the process comprising:

clarifying the wastewater stream in a primary clarifier and producing a primary effluent;

directing a first portion of the primary effluent to a biological treatment reactor and removing carbon from the primary effluent to produce treated wastewater;

after treating the first portion of the primary effluent in the biological treatment reactor, directing the treated wastewater into an integrated fixed film activated sludge (IFAS) deammonification reactor that is provided with intermittent aeration, including periods of air on and periods of air off;

directing a second portion of the primary effluent to an anaerobic or anoxic selector located upstream of the IFAS deammonification reactor and in the anaerobic or anoxic selector, selecting biological phosphorus removing microorganisms and non-filamentous microorganisms;

directing an effluent from the anaerobic or anoxic selector into the IFAS deammonification reactor and in the process bypassing the biological treatment reactor;

injecting the effluent from the anaerobic or anoxic selector into the IFAS deammonification reactor wherein the effluent from the anaerobic or anoxic selector is mixed with the treated wastewater in the IFAS deammonification reactor to form a wastewater mixture;

in the IFAS deammonification reactor, removing ammonium from the wastewater mixture by a nitritation and an anammox process and removing phosphorus from the wastewater mixture; and

directing the wastewater mixture from the IFAS deammonification reactor to a secondary clarifier and producing a secondary effluent and a clarifier underflow and recycling a portion of the clarifier underflow to the anaerobic or anoxic selector.

In another aspect, there is provided a mainstream deammonification process for removing ammonium from a wastewater stream, comprising:

clarifying the wastewater stream in a primary clarifier and producing a primary effluent;

directing a first portion of the primary effluent to a biological treatment reactor and removing carbon from the primary effluent to produce treated wastewater;

after treating the first portion of the primary effluent in the biological treatment reactor, directing the treated wastewater to an integrated fixed film activated sludge (IFAS) deammonification reactor provided with intermittent aeration including periods of air on and periods of air off and wherein the IFAS deammonification reactor includes a series of basins;

step feeding the treated wastewater into the basins of the IFAS deammonification reactor;

directing a second portion of the primary effluent to the IFAS deammonification reactor and in the process bypassing the biological treatment reactor;

step feeding the second portion of the primary effluent into the basins of the IFAS deammonification reactor during periods of air on and refraining from step feeding the second portion of the primary effluent into the IFAS deammonification reactor during periods of air on, wherein the second portion of a primary effluent is mixed with the treated wastewater in the IFAS deammonification reactor to form a wastewater mixture;

in the IFAS deammonification reactor, removing ammonium from the wastewater mixture by a nitritation and anammox process; and

after removing ammonium from the wastewater mixture, directing the wastewater mixture to a secondary clarifier and producing a secondary effluent and a clarifier underflow, and recycling at least a portion of the underflow to the IFAS deammonification reactor.

In one example, there is provided a mainstream deammonification process that includes an integrated fixed film activated sludge (IFAS) reactor for removing ammonium from a wastewater. The wastewater is subjected to primary clarification which produces a primary effluent. A portion of the primary effluent is directed to a biological treatment reactor for removing carbon from the wastewater. Effluent from the biological treatment unit is directed to the IFAS reactor which, through a deammonification process, removes ammonium from the wastewater. Another portion of the primary effluent bypasses the biological treatment reactor and is directed into the IFAS reactor or to an anaerobic or anoxic selector which selects organisms that give rise to the selection of biomass that has good settling characteristics. The readily biodegradable COD fraction in the primary effluent bypass flow is the substrate that is needed for the selection.

In one example, a deammonification process comprises nitritation and anammox processes which are employed to remove ammonium from the wastewater in the IFAS reactor. By selectively creating anoxic conditions in the IFAS reactor for limited periods of time, a partial denitrification process results which augments the deammonification process by converting nitrate to nitrite.

The present disclosure, in one example, entails a mainstream deammonification process for removing ammonium from a wastewater stream. The process comprises:

clarifying the wastewater in a primary clarifier and producing a primary effluent;

directing a portion of the primary effluent to a biological treatment reactor and removing carbon from the wastewater;

directing the wastewater from the biological treatment reactor to an IFAS deammonification reactor provided with intermittent aeration including periods of air on and periods of air off;

in the IFAS deammonification reactor, removing ammonium from the wastewater by a nitritation and anammox process;

directing the wastewater from the IFAS deammonification reactor to a secondary clarifier and producing a secondary effluent and a clarifier underflow, a portion of which is returned to the IFAS deammonification reactor;

directing a portion of the primary effluent directly to the IFAS deammonification reactor and in the process bypassing the biological treatment reactor; and

injecting the primary effluent into the IFAS deammonification reactor during period of off air and reframing from injecting the primary effluent into the IFAS deammonification reactor during periods of air on.

In another example, the present disclosure entails a mainstream deammonification process for removing ammonium and phosphorus from a stream of wastewater while reducing the tendency of sludge produced in the process to bulk. The process comprises:

clarifying the wastewater stream in a primary clarifier and producing a primary effluent;

directing a first portion of the primary effluent to a biological treatment reactor and removing carbon from the primary effluent to produce treated wastewater;

after treating the first portion of the primary effluent in the biological treatment reactor, directing the treated wastewater into an integrated fixed film activated sludge (IFAS) deammonification reactor that is provided with intermittent aeration, including periods of air on and periods of air off;

directing a second portion of the primary effluent to an anaerobic or anoxic selector located upstream of the IFAS deammonification reactor and in the anaerobic or anoxic selector, selecting biological phosphorus removing microorganisms and non-filamentous microorganisms;

directing an effluent from the anaerobic or anoxic selector into the IFAS deammonification reactor and in the process bypassing the biological treatment reactor;

injecting the effluent from the anaerobic or anoxic selector into the IFAS deammonification reactor wherein the effluent from the anaerobic or anoxic selector is mixed with the treated wastewater in the IFAS deammonification reactor to form a wastewater mixture;

in the IFAS deammonification reactor, removing ammonium from the wastewater mixture by a nitritation and an anammox process and removing phosphorus from the wastewater mixture; and

directing the wastewater mixture from the IFAS deammonification reactor to a secondary clarifier and producing a secondary effluent and a clarifier underflow and recycling a portion of the clarifier underflow to the anaerobic or anoxic selector.

In another example, the present disclosure entails a mainstream deammonification process for removing ammonium from a wastewater stream, comprising

clarifying the wastewater stream in a primary clarifier and producing a primary effluent;

directing a first portion of the primary effluent to a biological treatment reactor and removing carbon from the primary effluent to produce treated wastewater;

after treating the first portion of the primary effluent in the biological treatment reactor, directing the treated wastewater to an integrated fixed film activated sludge (IFAS) deammonification reactor provided with intermittent aeration including periods of air on and periods of air off and wherein the IFAS deammonification reactor includes a series of basins;

step feeding the treated wastewater into the basins of the IFAS deammonification reactor;

directing a second portion of the primary effluent to the IFAS deammonification reactor and in the process bypassing the biological treatment reactor;

step feeding the second portion of the primary effluent into the basins of the IFAS deammonification reactor during periods of air on and refraining from step feeding the second portion of the primary effluent into the IFAS deammonification reactor during periods of air on, wherein the second portion of a primary effluent is mixed with the treated wastewater in the IFAS deammonification reactor to form a wastewater mixture;

in the IFAS deammonification reactor, removing ammonium from the wastewater mixture by a nitritation and anammox process; and

after removing ammonium from the wastewater mixture, directing the wastewater mixture to a secondary clarifier and producing a secondary effluent and a clarifier underflow, and recycling at least a portion of the underflow to the IFAS deammonification reactor.

## BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a mainstream deammonification process where primary effluent is directed into an IFAS deammonification reactor.

Figure 2 shows a mainstream deammonification process similar to Figure 1 but with an anaerobic or anoxic selector upstream of the IFAS reactor.

Figure 3 shows a mainstream deammonification process similar to Figure 1 but including multiple IFAS deammonification reactors.

## DESCRIPTION OF EXEMPLARY EMBODIMENTS

Figures 1-3 show mainstream deammonification processes. Each process includes one or more IFAS deammonification reactors that remove ammonium from a wastewater stream. Further, each process includes some form of pretreatment. Pretreatment can vary. In the examples shown in Figures 1-3, the pretreatment includes a primary clarifier and some means to remove carbon from the wastewater. In the processes shown in Figures 1-3, there is