Summary

It is an object of the invention to at least partly overcome one or more of the above-identified limitations of the prior art. In particular, it is an object to provide a system for monitoring rodents that provide data that can provide a good overall understanding of the rodent populations and their movement in a city. Still further, it is an additional object to provide data based on which reliable predictions can be made.

According to a first aspect a system for monitoring rodents in a sewage system is provided. The system comprises

a plurality of monitoring devices placed in manholes of the sewage system, wherein each monitoring device is provided with one or several sensors configured to detect rodents in the sewage system and to generate a sensor data set, a memory configured to hold an identification code, and a data communications module,

a server comprising a data communications module communicatively connected to the data communication modules of the monitoring devices, wherein said server is configured to receive, from each monitoring device, the sensor data set and the identification code, and based on these data sets identify how populations of rodents move in the sewage system

wherein the identification code is linked to a position data set, wherein the position data set comprises information about a geographical position of the monitoring device.

An advantage of having sensor data sets from different monitoring devices sent to a server, is that over time, movements of the rodent populations in the sewage system can be learned, and in doing so, rodent outbreaks can be predicted.

In addition, by using the information about rodent movements in combination with information on how the different manholes are connected to each other, anomalies in the rodent movements may be used for detecting blockages or leakages in the sewage system. This information may be relevant for achieving efficient pest control, but also for detecting problems related to the sewage system itself and how waste water is handled.

By linking the identification code to the geographical position upon installation, the sensor data sets can easily be linked to locations in the sewage system. This has the advantage that an improved understanding of a condition of the sewage system can be provided at different points of time. The presence or non-presence of rodents, or the level of rodent presence, in different parts of the sewage system may namely be related to pipe breakages, flooding, chemical emissions, changed noise levels and/or other changed conditions in the sewage system that may result in that the rodents are

the threshold can be used for training the models to more accurately remove false positives.

Since the presence of rodents correlates to decreased levels of hydrogen sulfide under certain conditions, having information about the hydrogen sulfide level in the different manholes will improve the prediction of rodent outbreaks.

For each monitoring device, at least one of the one or several sensors may be configured as a level sensor such that a water level in each manhole is detected.

By having information not only on rodent activity, but also the water level in the different manholes, more reliable predictions can be made. Increased water levels in the manholes may namely force the rodents out of the sewage system.

In case water flow sensors are also used, the combination of rodent activity, water level data, and water flow data can be used for predicting rodent outbreaks. Rodent outbreaks can also be predicted by using the combination of rodent activity and the water flow data.

In addition to monitoring rodents, the monitoring devices may be configured to detect insects, such as American cockroaches, residing in the manholes. The same sensors as are used for detecting the rodents may also be used for detecting the insects, or there may different sensors for detecting the rodents and the insects, respectively. A sensor type that can be used both for detecting the rodents and the insects is the microphone. Another sensor type that can be used both for detecting the rodents and the insects is the radar sensor. For instance, the radar sensor can be used both for detecting the insects crawling on an inside of the manhole and the rodents running in the laterals connected to the manhole.

According to a second aspect a monitoring device for monitoring rodents in a sewage system is provided. The device being arranged to form part of the system. The device may comprise

one or several sensors configured to detect rodents in the sewage system and to generate a sensor data set,

a memory configured to hold an identification code, and

a data communications module communicatively connected to a server.

The same features and advantages presented above with respect to the first aspect also apply to this second aspect.

The device may further comprise

an attachment element arranged to interact with an inside surface of a manhole of the sewage system or an underside of a manhole cover arranged to cover the manhole.

The attachment element may be a rod-shaped element arranged to rest on a first and a second protrusion provided on the inside surface of the manhole.

At least one of the one or several sensors may be configured as a level sensor such that a water level in the manhole is detected.

At least one of the one or several sensors may be a water flow sensor such that a water flow rate is measured. These sensors may be using sound waves, such as ultrasonic waves, and/or light waves for measuring the flow rate.

According to third aspect a method for predicting a rodent outbreak in a city using the system is provided. The method may comprise

collecting sensor data sets from a plurality of monitoring devices placed in manholes or sewer pipes of a sewage system, during a data collection period comprising a plurality of sample time slots,

linking the sensor data sets to the manholes,

detecting rodent activity in each manhole during the sample time slots of the data collection phase, and

forecasting, for a future period, based on the rodent activity determined in the manholes during the data collection phase, when and where rodents are forced out of the sewage system.

In line with the features and advantages presented above with respect to the first aspect, an advantage with this third aspect is that reliable rodent outbreak predictions can be made by combining sensor data from different manholes captured over a period of time such that rodent movements can be determined.

The method may further comprise

determining water level sensor data in the manholes during the data collection period, and

wherein the step of forecasting, for the future period, when and where the rodents are forced out of the sewage system are based on the rodent activity detected in the manholes in combination with the water level sensor data determined during the data collection period.

As presented above, by also combining water levels in the different manholes, more accurate predictions of rodent outbreaks can be made.

The method may further comprise

receiving weather forecast data during the data collection period,

determining a weather forecast-water level relationship between the weather forecast data and the water level sensor data in the manholes during the data collection period,

receiving weather forecast data for the future period,

determining weather forecast water levels, for the future period, based on the weather forecast data for the future period and the weather forecast-water level relationship,

wherein the step of forecasting, for the future period, when and where the rodents are forced out of the sewage system are based on the rodent activity detected in the manholes during the data collection period in combination with the weather forecast water levels determined based on the weather forecast data for the future period.

An advantage of also taking into account weather forecast data is that the rodent outbreak prediction can be made more accurately. The method may further comprise

determining water flow data in the manholes during the data collection period, and

wherein the step of forecasting, for the future period, when and where the rodents are forced out of the sewage system are based on the rodent activity detected in the manholes in combination with the water flow data determined during the data collection period.

According to a fourth aspect a method for identifying a position for placing a trap in a sewage system using the system is provided. The method may comprise

collecting sensor data sets from a plurality of monitoring devices placed in manholes of the sewage system, during a data collection period comprising a plurality of sample time slots,

linking the sensor data sets to the manholes,

detecting rodent activity in each manhole during the sample time slots of the data collection phase,

identifying a least two candidate positions for placing a trap in the sewage system,

evaluating, by simulation, effects on rodent populations in the sewage system for the trap placed in the at least two candidate positions for a future period, and

selecting a most promising candidate position of the at least two candidate positions by comparing the effects associated with the at least two candidate positions with pre-set selection requirements, and

identifying the most promising candidate position as the position for placing the trap.

An effect of being able to make predictions on how rodents are likely to move within a sewage system is that it is also made possible to determine where to place a new trap to provide for that the rodent population is controlled.

According to a fifth aspect a method for identifying positions for existing traps in a sewage system using the system is provided. The method may comprise

collecting sensor data sets from a plurality of monitoring devices placed in manholes of the sewage system, during a data collection period comprising a plurality of sample time slots,

linking the sensor data sets to the manholes,

detecting rodent activity in each manhole during the sample time slots of the data collection phase,

receiving positions for the existing traps,

identifying a least two candidate position data sets for placing the existing traps in the sewage system,

evaluating, by simulation, effects on rodent populations in the sewage system for the traps placed in the at least two candidate position data sets for a future period, and

selecting a most promising candidate position data set of the at least two candidate position data sets by comparing the effects associated with the at least two candidate position data sets with pre-set selection requirements, and

identifying the most promising candidate position data sets as the positions for the existing traps.

According to a sixth aspect a method for identifying a blockage in a sewage system using the system is provided. The sewage system comprising a plurality of manholes connected by laterals, said method may comprise

continuously collecting sensor data sets from a plurality of monitoring devices placed in the manholes,

continuously detecting rodent activity in each manhole,

identifying the blockage in a lateral connecting two of the manholes by detecting a decreasing rodent activity in at least one manhole connected to the lateral.

Since a blockage in the lateral connecting two manholes to each other has an effect on the rodent activity in the different manholes, it is possible to detect blockages by continuously monitoring rodent activity. Thus, by using the rodents as information carriers in this way, problems in the sewage systems can accurately and quickly be identified.

According to a seventh aspect a method for identifying a position of an underground leakage in a sewage system using the system is provided. The sewage system may comprise a plurality of manholes connected by laterals. The method may comprise

collecting sensor data sets from a plurality of monitoring devices placed in the manholes over a period of time,

generating a first time series providing rodent activity in each manhole using the sensor data sets over the period of time,

detecting water level sensor data for each manhole,

generating a second time series providing water levels in each manhole using the water level sensor data over the period of time,

identifying the position of the underground leakage in the sewage system by combining the first and second time series.

In addition, the method may further comprise

detecting water flow data in laterals by using flow sensors placed in the laterals,

generating a third time series providing water flows in the laterals using the water flow data over a period of time,

wherein the step of identifying the position of the underground leakage in the sewage system is made by combining the first, second and third time series.

In a similar manner as the blockage can be detected, it is also possible to detect an underground leakage, either causing an inflow of water or an outflow of water. By being able to reliably and quickly detect such leakage, measures can be made quickly to reduce the impact of such leakage. Since a leakage may also provide access for the rodents to new buildings, this is also advantageous from a pest control perspective.

According to an eighth aspect it is provided a method for predicting a pest outbreak using the system. The method may comprise

collecting sensor data sets, such as temperature data, water flow data and/or water level sensor data, from at least one monitoring device placed in a sewage system, during a data collection period comprising a plurality of sample time slots,

detecting pest activity, such as rodent activity and/or insect activity, in the manhole during the sample time slots of the data collection phase, and

estimating, for a future period, based on the pest activity determined during the data collection phase, a risk of an insect outbreak.

The insect outbreak can be defined as an exponential population growth resulting in that the insects are forced out from the manhole.

The pest outbreak may comprise a rodent outbreak and/or an insect outbreak,.

The method may further comprise, in case the risk of pest outbreak is above a threshold, transmitting a notification to a user device such that actions can be made to mitigate the risk.

The monitoring device used may be the same monitoring device as is used for performing the method according to the third aspect, the fourth aspect, the fifth aspect, the sixth aspect and/or the seventh aspect.

The sensor data sets collected may further comprise sound data sets and/or radar data sets.

The estimation of the risk of the pest outbreak may be made by using an artificial intelligence (AI) based model, such as a neural network. Training data for such model may be collected from several monitoring devices in different manholes.

Still other objectives, features, aspects and advantages of the invention will appear from the following detailed description as well as from the drawings.

Brief Description of the Drawings

Embodiments of the invention will now be described, by way of example, with reference to the accompanying schematic drawings, in which

Fig. 1 generally illustrates a system for monitoring rodents in a sewage system.

Fig. 2 illustrates the system illustrated in fig. 1, but with water present in laterals.

Fig. 3 illustrates the system illustrated in fig. 1 and 2, but with water present in the laterals and in part of the manholes.

Fig. 4 illustrates a monitoring device according to a first embodiment.

Fig. 5 illustrates the monitoring device according to a second embodiment.

Fig. 6 illustrates the monitoring device in further detail.

Fig. 7 illustrates a sewage system depicted on a city map.

Fig. 8 illustrates how data is provided to and from a server of the system illustrated in fig. 1, 2 and 3.

Fig. 9 is a flowchart illustrating a method for forecasting a rodent outbreak.