

SYSTEM, METHOD AND USE FOR MONITORING AN ENVIRONMENTAL
CONDITION IN A STORM DRAIN

Technical Field

The present invention generally relates to a system and a method for monitoring an environmental condition in a storm drain using sensors located
5 within the storm drain. The invention also relates to a use of the system.

Background Art

Storm water, which also is called urban runoff, is surface runoff of rainwater, melted snow or ice, wash water or similar from different types of
10 surfaces. Such surfaces may be parking lots, sidewalks, roofs, and similar surfaces, sometimes referred to as impervious surfaces. Water running off from such surfaces tends to become polluted by e.g. gasoline, oil, heavy metals, trash, fertilizers, pesticides and other pollutants. During rain and periods of snow melting, these surfaces carry polluted storm water to storm
15 drains. Storm drains are generally connected to a drainage system for discharge into receiving surface waters, such as a canal, a river, a lake, a reservoir, the sea, an ocean, or other surface waters, with or without treatment of the storm water before discharge.

Storm drains generally comprise a vertical pipe having an inlet, such as
20 a horizontal grated inlet or a side inlet, being connected to a drainage system. Such storm drains may comprise a catch basin, also called sump or gully-pot, for catching small objects, such as sediment, sand, gravel, pebbles, twigs, trash and similar. The catch basin serves as a water-filled trap for trapping objects and prevent such objects from entering the subsequent drainage
25 system. Such catch basins also prevent gases from the drainage system from escaping. Generally, storm water from the top of the catch basin drains into the subsequent drainage system.

There is a continuously growing global desire to reduce the amount of pollutants, foreign substances and similar reaching various water courses or
30 surface waters. In the strive to reduce the amount of pollutants reaching the water courses concerned, various strategies may be employed. For instance,

the storm water may be filtered when entering the storm drain or when resident within the storm drain, in order to reduce the amount of pollutants in the storm water. Another strategy is to lead the storm water to a purifying plant where the storm water is purified generally using different mechanical
5 and chemical purifying steps. Yet another strategy is to filter the storm water in the storm drain and subsequently lead the storm water to a purifying plant for a second subsequent cleaning.

Regardless of the strategy used to reduce the amount of pollutants in the storm water concerned, there is a need to be able to monitor what is
10 occurring in the storm drains for receiving storm water.

For instance, a sudden discharge of a pollutant into the storm drain may damage the filter device resident within the storm drain. Also a purifying plant connected to the storm drain concerned may become damaged if subjected to a sudden and/or considerable discharge of a pollutant.

15 Similarly, any sudden discharge of a pollutant into the storm drain may result in that the capacity of the filter resident in the storm drain is insufficient, thus allowing polluted storm water to leave the storm drain unfiltered or at least unsatisfactory filtered.

Another problem is that, as the filter resident in the storm drain
20 becomes saturated with pollutants, other objects or substances present in the storm water, the efficiency of the filter becomes reduced. As the filter becomes saturated the percolation capacity of the filter may also become reduced. As the percolation capacity of the filter is decreasing, the function of the storm drain may be affected, as the storm drain might no longer be able to
25 receive the required amount of storm water per unit time, due to the reduced percolation capacity of the filter. This condition of insufficient percolation capacity may lead to flooding or undesired discharge of pollutions as the storm drain is no longer capable of receiving a required amount of storm water.

30 Under various conditions, storm drains may become blocked or clogged leading to that no or just little storm water may enter the storm drain. Under such conditions, the storm drain is in principle out of operation as its ability of receiving storm water is significantly reduced or virtually non-

existent. Also a blocked or clogged storm drain may lead to flooding or undesired discharge of pollutions.

In order to avoid the above problems, storm drains and filters resident in storm drains are generally checked and emptied of foreign objects and substances at a regular basis. For instance the storm drain may be checked and its catch basin emptied once a year by means of a vacuum truck. This procedure do however only make sure that the storm drain or the filter is operating correctly, e.g. not being clogged, blocked or damaged, once a year. This means in practice that in the most extreme case it may take up to one year to detect that the storm drain or the filter is malfunctioning.

To monitor the function of the storm drain or the filter resident therein at shorter intervals is for natural reasons a time consuming and costly process.

Hence, there is a need for an improved system and method for monitoring an environmental condition in the storm drain.

Summary of the invention

According to a first aspect of the invention, the above is at least partly alleviated by a system for monitoring an environmental condition in a storm drain, the system comprising; a storm drain containing a filter device comprising a filter unit and a floating carrier for carrying the filter unit, at least one sensor arranged in the storm drain for determining an environmental condition in the storm drain, the at least one sensor being arranged in communication with a sub node for transmitting data regarding the determined environmental condition in the storm drain to the sub node, the sub node being arranged in communication with a main node for transmitting data regarding the determined environmental condition in the storm drain to the main node, the main node being arranged to process the data received in order to monitor the environmental condition in the storm drain.

By means of the invention it is possible to monitor an environmental condition in the storm drain, that is to monitor a physical quantity, a presence of a substance or similar in the storm drain. In order to do so one or several sensors are arranged within the storm drain.

By “sensor” is meant any type of device or entity being capable of sensing a condition of any kind in the storm drain. A sensor may for instance be configured to determine or sense a physical quantity such as the temperature or humidity in the storm drain, but may also be configured to
5 determine e.g. the presence of a substance in the storm drain. Similarly, a sensor may be configured to determine e.g. a pressure or a flow. Consequently, depending on what is to be determined, various kinds of sensors may be employed.

The sensor or sensors in the storm drain are arranged in
10 communication with or connected to a sub node. By arranging the sensors in communication with the sub node, information regarding the conditions as determined by the sensors may be transmitted to the sub node.

It should be noted that within the context of this application the term “being arranged in communication with” is to be interpreted as meaning any
15 type of connection between entities enabling transfer of data. The connection may be a physical galvanic connection, e.g. realized by means of conductive wires. The connection may alternatively be any type of wireless connection based on radio frequency communications or any other suitable wireless technology, such as an optical connection, an acoustic connection, an
20 inductive connection or the like.

The wording “sub node” is to be interpreted as any device or entity being capable of receiving data from a sensor and transmitting data to a second entity, such as a main node. Further, the sub node may employ capabilities of processing the data received from the sensor. For instance, the
25 sub node may convert the data from an analog format to a digital format or vice versa. The sub node may also compress, modulate, encrypt or in any other way alter the data received from the sensor.

By “data” is meant any representation of information, analog or digital. Further, the data may be, compressed, modulated, encrypted or modified in
30 any other way depending on the needs of the actual application in question.

The wording “main node” is to be interpret as any device being capable of receiving data from a second entity, such as a sensor or a sub node, to which second entity the main node has been arranged in communication.

Further, the main node may employ capabilities of processing the data received, e.g. in order monitor an environmental condition of a storm drain. For that reason the main node may be employed with a central processing unit, CPU, or similar. The CPU of the main node may run one of several
5 programs for e.g. monitoring an environmental condition in the storm drain. The main node may convert the data from an analog format to a digital format or vice versa. The main node may also compress, modulate, encrypt or in any other way alter the data received. The main node may further comprise storage capabilities such as a hard drive, a memory card or any other type of
10 volatile or non-volatile memory being capable of storing data.

The at least one sensor may be arranged in communication with the sub node by means of a radio frequency connection. By arranging the sensor in communication with the sub node by means of a radio frequency
connection, the sub node and the sensor may be located remote from one
15 another without the need of installing any physical connection between the sensor and the sub node. Further, the use of a radio frequency connection requires no line of sight between the sensor and the sub node. The use of a radio frequency connection is thus advantageous in that the installation becomes easy and at the same time insensitive to the relative positioning of
20 the sensor and the sub node.

The at least one sensor may be arranged on the filter unit of the filter device, on the floating carrier of the filter device, or in the storm drain in a position separate from the filter device. This is advantageous in that the position of the sensor may be altered depending on the need. By arranging
25 the sensor on the filter unit of the filter device, physical quantities related to the filter unit may be measured, as the sensor is brought in contact with the filter unit. In addition to the above, the sensor may easily be exchanged or inspected when exchanging the filter unit. Similarly, by arranging the sensor on the floating carrier, physical quantities related to the floating carrier or to
30 the storm water in which it floats, may be measured. Further, the sensor may be exchanged or inspected when exchanging or inspecting the floating carrier. In addition to the above, the sensor may be arranged in any other position in the storm drain, such as in the storm water present in the catch

basin or in the air filled vertical pipe above the filter device. For natural reasons, the arrangement of the sensor in question will depend on the condition to be measured, meaning that the sensor may be arranged in a, for the particular application, favorable position in the storm drain.

- 5 The at least one sensor may be chosen from the group consisting of: a pressure sensor, a flow sensor, a temperature sensor, a humidity sensor, a light sensor, a gas sensor, a carbon dioxide sensor, an acceleration sensor, a hydro carbon sensor, an electrical field distribution sensor and an electrical field penetration sensor. This is advantageous in that a sensor suitable for the
10 current need may be chosen.

 The sub node may be arranged in communication with the main node by means of a radio frequency connection. A radio frequency connection exhibits several advantages, as discussed above.

- The main node may be arranged in communication with at least one
15 external sensor arranged outside the storm drain for determining an environmental condition outside the storm drain, the communication being direct from the external sensor outside the storm drain to the main node or indirect to the main node by means of a sub node. By arranging an external sensor outside the storm drain, an environmental condition outside the storm
20 drain may be determined. By determining an environmental condition outside the storm drain conclusions regarding conditions external to the storm drain may be drawn, such as the weather, the temperature, the light conditions or precipitation. The conclusions drawn may then be used as a basis for monitoring an environmental condition in the storm drain. Further, by
25 arranging the external sensor outside the storm drain in communication with the main node, either directly or indirectly by means of a sub node, data from the external sensor outside the storm drain may be transmitted to the main node, where it may for example be stored, processed or transmitted further.

- The at least one external sensor arranged outside the storm drain may
30 be chosen from the group consisting of: a temperature sensor, an oxygen sensor, a carbon dioxide sensor, a moisture sensor, a light sensor, an acceleration sensor and a combustion gas sensor. This is advantageous in that a sensor suitable for the current need may be chosen.

The main node may be arranged in communication with at least one remote resource, which is advantageous in that the main node may communicate with and transmit data to and/or receive data from the remote resource.

- 5 The wording “remote resource” is to be interpreted as any remotely located resource with which the main node may communicate. The remote resource may for example be a server or several servers located remote from the main node. Further, the remote resource may be a data base which is updated or complemented by data transmitted from the main node.
- 10 Analogous, the remote resource may be a database from which the main node may retrieve data. Similarly, the remote resource may be a data base which may be updated or complemented by data transmitted from the main node, and from which data base the main node may also retrieve data. Further, the remote resource may be an asset management system used to
- 15 monitor and manage one or several systems of the above type. In addition the remote resource may be a Geographical Information System, GIS, or a digital map, used to monitor and manage one or several systems of the above type. The remote resource may also be a mobile device, such as a mobile phone, a pager or similar. The remote resource may comprise a plurality of
- 20 resources of the same type or a mixture of resources of various types.

As is apparent, the remote resources may for natural reasons have various functions depending on the needs of the specific application.

- The main node may be arranged in communication with the at least one remote resource by means of a radio frequency connection. As
- 25 discussed above, a radio frequency connection exhibits several advantages.

- According to a second aspect of the invention, there is provided a method for monitoring an environmental condition in a storm drain, the method comprising; providing a storm drain containing a filter device comprising a filter unit and a floating carrier for carrying the filter unit,
- 30 arranging at least one sensor in the storm drain, determining an environmental condition in the storm drain using the at least one sensor, arranging the at least one sensor in communication with a sub node, transmitting data regarding the determined environmental condition in the storm drain from the at least one sensor to the sub node, arranging the sub

node in communication with a main node, transmitting data regarding the determined environmental condition in the storm drain from the sub node to the main node, arranging the main node to process the data received in order to monitor the environmental condition in the storm drain. In general, features
5 of this second aspect of the invention provide similar advantages as discussed above in relation to the first aspect of the invention.

The method may further comprise, arranging at least one external sensor outside the storm drain, determining an environmental condition outside the storm drain, and arranging the at least one external sensor
10 arranged outside the storm drain in communication with the main node, the communication being direct from the external sensor outside the storm drain to the main node or indirect to the main node by means of a sub node.

The method may further comprise, arranging the main node in communication with at least one remote resource.

15 The method may further comprise, providing at least one additional storm drain containing a filter device comprising a filter unit and a floating carrier for carrying the filter unit, arranging at least one additional sensor in the at least one additional storm drain, determining an environmental condition in the at least one additional storm drain using the at least one
20 additional sensor, arranging the at least one additional sensor in communication with an additional sub node, transmitting data regarding the determined environmental condition in the at least one additional storm drain from the at least one additional sensor to the additional sub node, arranging the additional sub node in communication with the main node, transmitting
25 data regarding the determined environmental condition in the at least one additional storm drain from the additional sub node to the main node, transmitting data regarding the determined environmental condition outside the storm drain from the at least one external sensor arranged outside the storm drain to the main node, determining by means of the main node, based
30 on the determined environmental condition outside the storm, an expected range for the determined environmental condition in the storm drain and an expected range for the determined environmental condition in the at least one additional storm drain, comparing by means of the main node, the determined

environmental condition in the storm drain and the determined environmental condition in the at least one additional storm drain with the expected ranges respectively, generating a signal by means of the main node if the determined environmental condition in the storm drain or the determined environmental condition in the at least one additional storm drain is determined not to be included in the expected ranges respectively, wherein the signal at least being indicative of which storm drain has a determined environmental condition not included in its expected range.

By providing at least one additional storm drain, and monitoring an environmental condition in the additional storm drain as well as in the initial storm drain, several storm drains may be monitored simultaneously.

In addition, by determining an environmental condition outside the storm drains, conclusions regarding the conditions outside the storm drains may be drawn.

For instance, it is possible to detect the current weather and any precipitation, such as rain. Consequently, if the flow of storm water is determined and monitored in storm drains of the area where it rains, it could be expected that a flow of storm water is to be detectable in the storm drains during the rain. Given this, it is thus possible to detect, if for instance a storm drain is blocked or clogged or only has a reduced percolation capacity, by comparing the determined flows of the storm drains with expected flow ranges determined by the main node.

Similarly, it is also possible to detect a local leak of water or any other liquid if a flow is detected in a storm drain when it is not raining.

It is thus possible to generate a signal by means of the main node to indicate a potential malfunction of a storm drain or even worse a discharge of a pollution. The signal may comprise data indicative of the storm drain in question. The signal may also comprise additional information such as information concerning which environmental condition has been used to detect the potential malfunction, the determined value for the environmental condition in question or any other suitable information.

The method may further comprise, storing the signal in the main node or transmitting the signal from the main node to the at least one remote

resource. This is advantageous in that the signal may be read out upon request or transmitted to a remote resource. By transmitting the signal to the remote resource a faster detection of a potential malfunction may be acquired.

5 According to another aspect of the invention, there is provided a use of the above system for monitoring an environmental condition in a storm drain.

 Further features of, and advantages with, the present invention will become apparent when studying the appended claims and the following description. The skilled person will realize that different features of the
10 present invention may be combined to create embodiments other than those described in the following, without departing from the scope of the present invention.

Brief Description of the Drawings

15 The aspects of the invention, including some its particular features and advantages, will be readily understood from the following detailed description and the accompanying drawings, in which:

 Fig. 1 is a schematic view of the system according to an embodiment of the invention.

20 Fig. 2 is a schematic flow chart of the method according to an embodiment the invention.

Detailed Description

 The present invention will now be described more fully hereinafter with
25 reference to the accompanying drawings, in which currently preferred embodiments of the invention are shown. The invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided for thoroughness and completeness, and fully convey the scope of the
30 invention to the skilled person. Like reference characters refer to like elements throughout.

 Referring now to the drawings and to Fig. 1, there is conceptually depicted a system 100 for monitoring one or several environmental conditions

in one or several storm drains 102, 104. Each storm drain 102, 104, in which one or several environmental conditions are to be monitored, may be employed with sensors, 106, 108, 110, 112, 114. Further each storm drain 102, 104 may be employed with a sub node 116, 118. In Fig. 1 two storm drains 102, 104 are shown, it is however to be understood that more storm drains, not shown, and consequently more sensors, not shown, and more sub nodes, not shown, may be used in the system 100. Further, the sensor and sub node configuration shown in Fig. 1 is just an exemplifying configuration. Hence, it is to be understood that two or more storm drains 102, 104 may have the same sensor configuration and the same sub node configuration. Further, when a plurality of storm drains 102, 104 are used in the system 100, some of the storm drains 102, 104 may have the same sensor and/or sub node configuration, but at the same time other storm drains 102, 104, may have different sensor and/or sub node configurations.

A main node 120 may be mounted in an elevated position outside of the storm drains 102, 104, that are to be monitored. Further, external sensors 122, 124 are connected to the main node.

The main node 120 may in turn be connected to remote resources 126, 127 through a data channel of a mobile telephony system 128 or similar. The connection from the main node 120 to the remote resources 126, 127 may be direct by means of e.g. a radio frequency connection and/or may use other suitable communications, such as a local area network, LAN, a wide area network, WAN, the internet or similar. It is to be understood that any number of remote resources 126, 127, including one, may be used in the system 100. Also, it is to be understood that any suitable data channel may be used to connect the main node 120 to the remote resources 126, 127.

The disclosed storm drains 102, 104 are both employed with a filter device 134. The filter device 134 comprises a filter unit 130 and a floating carrier 132 respectively.

Now referring to the sensor and sub node configuration of the storm drain 102. As is shown in Fig. 1, the exemplified storm drain 102 is employed with three different sensors 106, 108, 110. The different sensors 106, 108, 110 are mounted in different locations within the storm drain 102. Sensor 106

is mounted on the filter unit 130 of the filter device 134. Correspondingly, sensor 108 is mounted on the floating carrier 132 of the filter device 134, whereas sensor 110 is mounted separate from the filter device 134 present in the storm drain 102. In other words, sensor 110 is mounted in a position
5 separate from the filter device 134. In this particular case, sensor 110 is mounted on an inner wall of the storm drain 102. All three sensors 106, 108, 110 are arranged in communication with the sub node 116 present in the storm drain 102. The sub node 116 is exemplified as being mounted on the filter unit 130. However, different positions of the sub node 116 are possible
10 as disclosed above. The disclosed sensors 106, 108, 110 are arranged in communication with or connected to the sub node 116 in different ways. Sensor 106 is connected to the sub node 116 using a wire connection, meaning that the sensor 106 is connected to the sub node 116 by means of traditional conductive wires. In other words, the sensor 106 is galvanically
15 connected to or arranged in communication with the sub node 116. On the other hand, sensors 108, 110 are connected to the sub node 116 by means of a wireless connection. In this particular embodiment, sensors 108, 110 are connected to the sub node 116 using radio frequency communication. The Radio frequency communication used in the connection will be discussed
20 more in detail hereinafter.

Consequently, the sub node 116 may be employed with capabilities for communication with sensors 106, 108, 110 through both wireless and wired communication channels. In fact the sub node itself may be employed with sensors, not shown, present within the same housing. In this case the
25 sensors are generally connected to the sub 116 node by means of a wired connection.

In order to drive the sub node 116, the sub node 116 may be employed with a battery, not shown, or any other suitable energy source. The battery may be a rechargeable battery which may be recharged at regular intervals or
30 charged by e.g. a solar panel or similar connected to the sub node 116. The battery may also be a single use battery which has to be replaced at regular intervals, e.g. when replacing a filter unit 130 of a filter device 134.

Similarly, the exemplified storm drain 104 is employed with two different sensors 112, 114 arranged in different positions within the storm drain 104. In this case both sensors, 112, 114 are arranged in communication with a sub node 118 arranged on an inner wall of the storm drain 104. Both
5 sensors 112, 114 are wirelessly connected to the sub node 118. In the exemplified storm drain 104, the sub node is positioned differently as compared to the exemplified storm drain 102. However, different positions of the sub node 118 are possible as disclosed above.

Depending on the current need, different sensors or sensor
10 configurations including different sensor positions may be used, as will be discussed more in detail hereinafter.

Further, the sub nodes 116, 118 are employed with capabilities for being connected to or arranged in communication with the main node 120. The sub nodes 116, 118 are connected to the main node 120 by means of a
15 radio frequency connection. Details concerning the connection will be discussed more in detail hereinafter.

The exemplified main node 120 is as discussed above arranged in communication with two external sensors 122, 124. External sensor 122 is connected to the main node 120 by means of a wire connection, whereas
20 external sensor 124 is connected to the main node 120 by means of a wireless connection. The wireless connection between the external sensor 124 and the main node 120 may also in this case be realized using a radio frequency connection. Just like the sub nodes 116, 118, the main node 120 may comprise sensors, not shown, within the same housing as the main node
25 120 itself.

Further, the external sensors 122, 124 may be connected directly to the main node 120 or indirectly by means of an additional sub node, not shown. In fact any of the sub nodes 116, 118 may be used to connect the external sensors 122, 124 to the main node 120, as long as a radio frequency
30 connection may be established.

Further, the main node 120 may be powered by being connected to mains but may at the same time comprise a rechargeable backup battery for powering the main node 120 in case of a power failure. As is apparent, the

main node 120 may be powered only by being connected to mains or may be only battery powered.

Further, the exemplified main node is arranged in communication with two remote resources 126, 127. The main node 120 may be connected to the
5 remote resources 126, 127 by means of a radio frequency connection in form of a data channel of mobile telephony system 128. Generally, the data channel of a conventional mobile telephone system 128, such as a GSM/GPRS or an UMTS system, may be used. The skilled person realizes that also other suitable radio frequency connections may be used to connect
10 the main node 120 to the remote resources 126, 128.

The remote resource 126 of Fig. 1, may comprise a Geographical Information System, GIS. A GIS is generally a system designed to capture, store, manipulate, analyze, manage, and present any type of geographical data. In the shown embodiment, the GIS comprises a digital map on which
15 the respective storm drains 102, 104 are shown. Just to give a simple example, by selecting any of the storm drains 102, 104, further information concerning the selected storm drain may be accessed through the GIS. For instance storm drain 102 may be selected, and the location of the storm drain 102 and the identity of the filter device 134 resident therein may be retrieved.
20 Further, information pertaining to the measured environmental conditions in the selected storm drain 102 may be retrieved. For instance, a current condition as sensed by the sensors 106, 108, 110, may be retrieved from the GIS. Also historical data pertaining to previous conditions may be accessed through the GIS. The stored historical data of the GIS may by way of example
25 be subjected to data mining, which aims to find hidden patterns in the recorded data. The skilled person realizes that a GIS may be employed for several additional purposes than the above examples, and that a GIS may comprise additional functionality.

The remote resource 127 of Fig. 1 may be an asset management
30 system used to manage and monitor the storm drains 102, 104 and the filter devices 134 resident therein. The asset management system 127, comprises information of the monitored storm drains 102, 104 and of the filter devices 134 resident therein. The identity of each filter device 134 may be stored in

the asset management system. In fact each filter unit 130 and each floating carrier 132 may be employed with a unique identification number, UIN. The UIN may advantageously be stored in a passive RFID device or tag.

Several other remote resources 126, 127 are possible without
5 departing from the scope of the invention. For instance, a remote resource 126, 127 may be a cloud based storage service or a server based storage service. A remote resource 126, 127 may also be a data base used to store data from the respective sensors 106, 108, 110, 112, 114, 120, 122 included in the system 100. Further the remote resource 126, 127 may comprise data
10 pertaining to pollutions that are to be monitored or may comprise data pertaining to the filter devices 134 in the monitored storm drains 102, 104.

Now referring to the main node 120 of Fig. 1. The exemplified main node 120 comprises capabilities of processing data received from the sub nodes 116, 118 or the external sensors 122, 124, connected thereto. For that
15 reason the main node 120 may be employed with a central processing unit, CPU. The main node 120 may run an operating system. Preferably, the main node may run Windows Mobile an embedded XP operation system, Apple iOS, Android or other Apple compatible operation systems. The main node 120 may however run other suitable operating systems.

20 As the main node 120 of Fig. 1 comprises capabilities of processing data, the main node 120 may be set up to monitor the environmental conditions as determined by the sensors 106, 108, 110, 112, 114, 120, 122.

Further, the main node 120 of Fig. 1 may be set up to generate a signal if one of several of the determined environmental conditions are
25 determined to not fulfill a predetermined criteria. For instance, a signal may be generated by the main node 120 if any of the sensors 106, 108, 110, 112, 114 determines an environmental condition corresponding to the presence of a monitored pollution.

The signal generated may be sent to a remote resource and/or to an
30 operator. As the main node may be connected to the mobile telephone system 128 the signal may be sent as a SMS, Short Message Service, directly to the mobile or cellular phone of the operator. The signal may be sent to a specific mobile phone or to a group of mobile phones. Further, the

main node 120, may additionally place a call, send an email or similar to notify an operator.

Contrary, the operator may request a current status by e.g. sending an SMS or similar to the main node 120.

5 Further, the main node of Fig 1 may be employed with storage capabilities for storing data. For instance, if the main node 120 may be located in a remote area where there is no mobile phone reception, data received and analyzed by the main node may have to be stored locally as it cannot be sent to any remote resource 126, 127. For this reason the main
10 node may be employed with an internal storage and/or a slot/connection for a removable storage media.

The exemplifying main node 120 of Fig 1 may be employed with a GPS receiver which may be used to determine the position of the main node 120. In addition, the main node 120, may be employed with an acceleration
15 sensor. By employing an acceleration sensor, it is possible to detect if the main node 120 is moved. A sudden movement of the main node 120 may be indicative of e.g. a theft attempt or of that the main node has been moved from its intended position.

Now referring to the sensors 106, 108, 110, 112, 114. In order to
20 determine environmental conditions in the storm drains 102, 104, various sensors 106, 108, 110, 112, 114 capable of sensing various conditions may be employed.

The temperature of the air or the water in the storm drain 102, 104 may be determined using different types of suitable temperature sensors. Also the
25 humidity of the air of the storm drain 102, 104 may be measured, by means of a humidity sensor. In addition the light level in the storm drain may be measured using a light sensor. Also a gas sensor being capable of sensing the presence of various gases may be employed in the storm drain 102, 104.

In order to sense pollutions in the water of the storm drain, a hydro
30 carbon sensor may be employed. The "Leakwise detection system" commercially available from GE is an example of a commercially available hydro carbon sensor system capable of detecting e.g. oil leaks.

As the filter unit 130 of the filter device 134 absorbs pollutions or similar, the weight of the filter unit 130 increases, meaning that the depth of the filter device 134 in the water of the storm drain 102, 104 increases. Thus, by employing a pressure sensor arranged on the filter device 134 below the surface of the water in the storm drain 102, 104, the pressure may be measured and the depth calculated. Consequently, it is possible to determine the remaining filter capacity by measuring the current depth of the filter device 134 in the water of the storm drain 102, 104.

Another approach that may be used to determine the presence of absorbed pollutions or similar in the filter unit 130 of the filter device 134 is to use an electrical field distribution sensor. By measuring an electrical field distribution in e.g. an electrically conductive grid present in the filter unit 130 alternations to the electrical field may be detected. As the grid becomes polluted its characteristics becomes altered. In other words, a clean grid with no pollutions will exhibit certain characteristics when subjected to an electrical field, whereas the same grid will exhibit different characteristics once polluted.

Yet another approach to determine the presence of absorbed pollutions or similar in the filter unit 130 of the filter device 134 may be to use a field penetration sensor. A field penetration sensor is a device which is used to determine how an electrical field penetrates an object. Generally a lower frequency has a better penetration capability as compared to a higher frequency. Consequently, it is possible to measure the presence of absorbed pollutions or similar in the filter unit 130 of the filter device 134 by exhibiting the filter unit 130 to an electrical field and measure how the electrical field penetrates the filter unit 130. In practice, the energy of the electrical field will have to be increased or the wave length of the electrical field will have to be lowered in order to have the electrical field penetrate the filter unit 130 as the filter unit absorbs pollutions or similar.

In practice, as discussed above, the sensors 106, 108, 110, 112, 114 may be selected to meet specific needs of a particular storm drain 102, 104. Just to give an example, if a storm drain is situated in a factory yard where there is an increased risk of oil spills or oil leakages, a sensor or sensors 106,

108, 110, 112, 114 capable of sensing oil may advantageously be provided in the storm drains 102, 104 to be monitored.

Similarly, if a storm drain 102, 104 is situated in an area where a discharge of fertilizers or pesticides are expected, sensors 106, 108, 110,
5 112, 114 capable of determining a presence of the fertilizers or pesticides in question, may be employed in order to monitor the expected discharge.

Hence, the skilled person realizes that different sensors 106, 108, 110, 112, 114 may be used depending on the current need, and that various types of sensors may be used to sense the same environmental condition.

10 Further, according to some embodiments, the main node 120 may be employed with external sensors for determining conditions external of the storm drains 102, 104 of the system 100. For instance, the main node 120 may comprise an external temperature sensor being capable of determining ambient temperatures between -40°C and 120°C with an accuracy of $\pm 0,3^{\circ}\text{C}$.
15 According to some embodiments the oxygen content, O_2 , and the carbon dioxide content, CO_2 , of the ambient air, external of the storm drains 102, 104 of the system 100, may be measured using suitable external sensors connected to the main node 120. The relative humidity of the ambient air may also be measured using a humidity sensor connected to the main node 120.

20 The skilled person realizes that several different types of external sensors may be employed in order to measure the above exemplifying parameters or other relevant parameters, external of the storm drains 102, 104 of the system 100.

For instance, several different temperature sensors using different
25 sensing techniques may be used in order to measure the temperature by or in proximity to the main node 120. Similarly, several different types of gas sensors and humidity sensors may be used. By measuring the above parameters, it is possible to draw conclusions regarding a current environmental conditions in proximity to the main node 120. For instance, the
30 relative humidity will increase to about 100% when it is raining. Similarly, the temperature will generally decrease as it starts to rain. Given this it is thus possible to detect e.g. a rainfall by means of the main node 120 and the external sensors 122, 124 connected thereto.

According to some embodiments, the main node 120 may be connected to a combustion gas sensor, which is capable of detecting combustion gases in the ambient air. Generally, a combustion gas sensor is configured to detect various common combustion gases, such as alkenes,
5 alkanes, acetylene, carbon dioxide and hydrogen. By employing a combustion gas sensor it is possible to determine e.g. a fire or a discharge of a combustion gases in proximity to the main node 120.

The skilled person realizes that other kinds of sensors may be employed to detect other environmental conditions in proximity to the main
10 node 120.

Now referring to the previously mentioned radio frequency connection. As has been discussed above, a radio frequency connection may be used between the sensors 108, 110, 112, 114 and their respective sub nodes 116, 118, between the sub nodes 116, 118 and the main node 120 as well as
15 between the external sensor 124 and the main node of Fig. 1. The radio frequency connection of Fig.1 may be based on a short range wireless link using a low transmission power. Due to legislative requirements only certain frequencies may be used. In different jurisdictions, different frequencies may be allowed and consequently used. According to currently preferred
20 embodiments 2,4 GHz or 433 MHz are used.

The radio frequency connection may preferably be set up as a dual-directional connection, meaning that data may be transmitted both to and from the sensors 108, 110, 112, 114, the sub nodes 116, 118 and the main node 120. Also a single directional connection capable of transferring data in
25 a single direction may be used. Preferably 433 MHz may be used to realize the downlink from the main node 120 to the sub nodes 116, 118 and from the sub nodes 116, 118 to the sensors 108, 110, 112, 114. Correspondingly, it is preferred to use 2,4 GHz to realize the uplink from the sensors 108, 110, 112, 114 to the sub nodes 116, 118 and from the sub nodes 116, 118 to the main
30 node 120. Typically the range of the 2,4 GHz uplink is over 100 m.

By utilizing a dual-directional connection it may not just be possible to monitor environmental conditions in a storm drain 102, 104, but also possible to e.g. reconfigure or reset the sub nodes 116, 118 and sensors 106, 108,

110, 112, 114, 122, 124 used. Just to give a few examples, the sampling interval of the sensors 106, 108, 110, 112, 114 may be reconfigured using the dual-directional connection described above. Similarly, some sensors 106, 108, 110, 112, 114, 122, 124 may be deactivated. The skilled person realizes
5 that several other operations to the sensors 106, 108, 110, 112, 114 and the sub nodes 116, 118 may be performed using the dual-directional connection described above.

Using the above described radio frequency connection, up to 200 sub nodes 116, 118 may be connected to the same main node 120.

10 Consequently, up to 200 storm drains 102, 104 may be monitored by means of the same main node 120.

The skilled person realizes that any suitable radio frequency connection may be used. For instance a communication based on RFID, Bluetooth, Zigbee or similar may be used.

15 Similarly, a plurality of main nodes 120 may be connected to the same remote resource 126, 127, meaning that any number of storm drains 102, 104 may be monitored using the same asset management system, GIS or similar.

In the following an embodiment of a method 200 according to the present invention for monitoring an environmental condition in a storm drain
20 will be schematically described, with reference to Fig. 2, which shows exemplifying steps of the method. The following non limiting examples of embodiments of an inventive method will for simplifying reasons be described when used in conjunction with a system 100 according to above.

In a first step 202 of the exemplifying method, a storm drain 102, 104
25 containing a filter device 134 comprising a filter unit 130 and a floating carrier 132 for carrying the filter unit 130 is provided.

In a second step 204 of the exemplifying method, at least one sensor 106, 108, 110, 112, 114 is arranged in the storm drain 102, 104. As discussed above, in conjunction with the system 100, the sensors 106, 108, 110, 112,
30 114 may be of various kinds and aimed at determining various environmental conditions in the storm drain 102, 104.

In a third step 206 of the exemplifying method, an environmental condition in the storm drain 102, 104 is determined using the at least one sensor 106, 108, 110, 112, 114.

5 In a fourth step 208 of the exemplifying method, the at least one sensor is arranged in communication with a sub node 116, 118. As discussed above, several options for arranging the sensor 106, 108, 110, 112, 114 in communication with the sub node 116, 118 may be used.

In a fifth step 210 of the exemplifying method, data regarding the determined environmental condition in the storm drain 102, 104 is transmitted
10 from the sensor 106, 108, 110, 112, 114 to the sub node 116, 118.

In sixth step 212 of the exemplifying method, the sub node 116, 118 is arranged in communication with a main node 120. Similarly, as discussed above, several options for arranging the sub node 116, 118 in communication with the main node 120 may be used.

15 In a seventh step 214 of the exemplifying method, data regarding the determined environmental condition in the storm drain 102, 104 is transmitted from the sub node 116, 118 to the main node 120.

In an eight step 116 of the exemplifying method, the main node 120 is arranged to process the data received in order to monitor the environmental
20 condition in the storm drain. As discussed above, the main node 120 may monitor the determined condition and based on the determined condition e.g. generate a signal for alerting an operator or a remote resource 126, 127.

According to an embodiment of the inventive method, at least one external sensor 120, 122 may be arranged outside the storm drain 102, 104
25 to determine an environmental condition outside the storm drain 102, 104. The external sensor 120, 122 may as discussed above be arranged in direct communication with the main node 120 or indirect communication by means of a sub node.

According to an embodiment of the inventive method, the main node
30 120 may be arranged in communication with at least one remote resource 126, 127. As discussed above, several different connections may be used to arrange the main node 120 in communication with the remote resource 126,

127. Further, as also discussed above, the remote resource 126, 127 may be of various kind.

According to an embodiment of the inventive method, at least one additional storm drain 104 may be provided. The at least one additional storm
5 drain may just like the initial storm drain 102 be provided with at least one sensor 112, 114 in communication with a sub node 118. The sub node 118 of the additional storm drain 104 may be provided in communication with the main node 120. Consequently, data regarding an environmental condition in the additional storm drain 104 may be transmitted from the sensor 112, 114 to
10 the sub node 118 and from the sub node 118 to the main node 120.

In the following, data regarding a determined environmental condition outside the storm drains 102, 104, as determined by the external sensor 122, 124 outside the storm drains 102, 104 may be transmitted to the main node 120.

15 In the following, it may be determined by means of the main node 120, based on the determined environmental condition outside the storm drains 102, 104, an expected range, i.e. an allowed tolerance, for the determined environmental condition in the storm drain 102 and an expected range for the determined environmental condition in the at least one additional storm drain
20 104. For instance if the environmental condition outside the storm drains 102, 104 is indicative of a rainfall, it is expected that storm water originating from the rainfall will enter the storm drain 102 and the additional storm drain 104. This means in practice that a flow of storm water into the storm drain 102 and the additional storm drain 104 should be detectable given that sensors 106,
25 108, 110, 112, 114 capable of determining a flow of storm water into the storm drain 102 and the additional storm drain 104 has been provided in the respective storm drains 102, 104.

It is thus possible, by means of the main node 120, to compare the determined environmental condition in the storm drain 102 and the additional
30 storm drain 104 with the expected range, e.g. a flow of water greater than 1 liter per minute for both the storm drain 102 and the additional storm drain 104.

Following this, a signal may be generated by means of the main node 120 if the determined environmental condition, e.g. the water flow, in the storm drain 102 or the determined environmental condition, e.g. the water flow, in the at least one additional storm drain 104 may be determined to not
5 be included in the expected ranges respectively. The signal generated may be indicative of which storm drain 102, 104 has a determined environmental condition not included in its expected range.

In the above example it is thus possible to detect that the flow of storm water is not as large as expected in one or both of the monitored storm drains
10 102, 104. Consequently, it is likely that a storm drain 102, 104 not having an expected flow of storm water is clogged, blocked or experiencing a similar problem.

Contrary, if a flow of storm water is detected into a storm drain 102, 104, at a time where no flow is expected based on the determined
15 environmental condition outside the storm drain, e.g. during a time with no rain, a signal may be generated as it is expected that no or only a limited amount of water is to enter the storm drain 102, 104. In case a plurality of storm drains 102, 104 are monitored, the signal may be indicative of which of storm drain 102, 104 has a determined condition not within an expected
20 range. That is, the signal may be indicative of which storm drain 102, 104 is experiencing a potential a malfunction.

Similarly, it is to be expected that light enters a storm drain 102, 104 during daytime, i.e. when light may be detected outside the storm drain 102, 104. It is thus possible to detect that a storm drain is clogged or blocked by
25 determining an expected light level within the monitored storm drains 102, 104. A light level not within its expected range may consequently be indicative of e.g. a blocking above the storm drain 102, 104 concerned. For instance, someone might have placed a dumpster or similar above the storm drain 102, 104.

30 The above described signal indicative of which storm drain 102, 104 has a determined environmental condition not included in its expected range may be stored in the main node 120 or transmitted to a remote resource 126, 127 or an operator, as discussed above.

Although the figures may show a specific order of method steps, the order of the steps may differ from what is depicted. Also two or more steps may be performed concurrently or with partial concurrence. Such variation will depend on the software and hardware systems chosen and on designer
5 choice. All such variations are within the scope of the disclosure. Additionally, even though the invention has been described with reference to a few specific exemplifying embodiments thereof, many different alterations, modifications and the like will become apparent for the skilled person. Variations to the disclosed embodiments may be understood and effected by the skilled person
10 in practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims. Furthermore, in the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality.

CLAIMS

1. System (100) for monitoring an environmental condition in a storm drain (102, 104), the system comprising;

a storm drain (102, 104), containing a filter device (134) comprising a filter unit (130) and a floating carrier (132) for carrying the filter unit (130),

at least one sensor (106, 108, 110, 112, 114) arranged in the storm drain (102, 104), for determining an environmental condition in the storm drain (102, 104),

the at least one sensor (106, 108, 110, 112, 114) being arranged in communication with a sub node (116, 118) for transmitting data regarding the determined environmental condition in the storm drain (102, 104) to the sub node (116, 118),

the sub node (116, 118) being arranged in communication with a main node (120) for transmitting data regarding the determined environmental condition in the storm drain (102, 104) to the main node (120), and

at least one external sensor (122, 124) arranged outside the storm drain (102, 104), wherein the main node (120) is arranged in communication with at least one external sensor (122, 124) arranged outside the storm drain (102, 104) for determining an environmental condition outside the storm drain (102, 104),

the main node (120) being arranged to process the data received in order to monitor the environmental condition in the storm drain (102, 104).

2. System (100) according to claim 1, wherein the at least one sensor (106, 108, 110, 112, 114) is arranged in communication with the sub node (116, 118) by means of a radio frequency connection.

3. System (100) according to claim 1 or 2, wherein the at least one sensor (106, 108, 110, 112, 114) is arranged on the filter unit (130) of the filter device (134), on the floating carrier (132) of the filter device (134), or in the storm drain (102, 104) in a position separate from the filter device (134).

4. System (100) according to any one of the preceding claims, wherein the at least one sensor (106, 108, 110, 112, 114) is chosen from the group consisting of; a pressure sensor, a flow sensor, a temperature sensor, a humidity sensor, a light sensor, a gas sensor, a carbon dioxide sensor, an acceleration sensor, a hydro carbon sensor, an electrical field distribution sensor, and an electrical field penetration sensor.

5. System (100) according to any one of the preceding claims, wherein the sub node (116, 118) is arranged in communication with the main node (120) by means of a radio frequency connection.

6. System (100) according to any one of the preceding claims, wherein the main node (120) is arranged in communication with the at least one external sensor (122, 124) direct from the external sensor (122, 124) outside the storm drain (102, 104) to the main node (120) or indirect to the main node (120) by means of a sub node.

7. System (100) according to any one of the preceding claims, wherein the at least one external sensor (122, 124) arranged outside the storm drain is chosen from the group consisting of; a temperature sensor, an oxygen sensor, a carbon dioxide sensor, a moisture sensor, a light sensor, an acceleration sensor and a combustion gas sensor.

8. System (100) according to any one of the preceding claims, wherein the main node (120) is arranged in communication with at least one remote resource (126, 127).

9. System (100) according to claim 8, wherein the main node (120) is arranged in communication with the at least one remote resource (126, 127) by means of a radio frequency connection.

10. Method (200) for monitoring an environmental condition in a storm drain (102, 104), the method comprising;

providing (202) a storm drain (102, 104) containing a filter device (134) comprising a filter unit (130) and a floating carrier (132) for carrying the filter unit (130),

arranging (204) at least one sensor (106, 108, 110, 112, 114) in the storm drain (102, 104),

determining (206) an environmental condition in the storm drain (102, 104) using the at least one sensor (106, 108, 110, 112, 114),

arranging (208) the at least one sensor (106, 108, 110, 112, 114) in communication with a sub node (116, 118),

transmitting (210) data regarding the determined environmental condition in the storm drain (102, 104) from the at least one sensor (106, 108, 110, 112, 114) to the sub node (116, 118),

arranging (212) the sub node (116, 118) in communication with a main node (120),

transmitting (214) data regarding the determined environmental condition in the storm drain (102, 104) from the sub node (116, 118) to the main node (120),

arranging at least one external sensor (122, 124) outside the storm drain (102, 104),

determining an environmental condition outside the storm drain (102, 104),

arranging the at least one external sensor (122, 124) arranged outside the storm drain (102, 104) in communication with the main node (120), and

arranging (216) the main node (120) to process the data received in order to monitor the environmental condition in the storm drain (102, 104).

11. Method (200) according to claim 10, wherein the arranging the at least one external sensor (122, 124) arranged outside the storm drain (102, 104) in communication with the main node (120), being direct communication from the external sensor (122, 124) outside the storm drain (102, 104) to the main node (120) or indirect communication to the main node (120) by means of a sub node (116, 118).

12. Method (200) according to claim 10 or 11, the method further comprising,

arranging the main node (120) in communication with at least one remote resource (126, 127).

13. Method (200) according to claim 11 or 12, the method further comprising,

providing at least one additional storm drain (104) containing a filter device (134) comprising a filter unit (130) and a floating carrier (132) for carrying the filter unit (130),

arranging at least one additional sensor (112, 114) in the at least one additional storm drain (104),

determining an environmental condition in the at least one additional storm drain (104) using the at least one additional sensor (112, 114),

arranging the at least one additional sensor (112, 114) in communication with an additional sub node (118),

transmitting data regarding the determined environmental condition in the at least one additional storm drain (104) from the at least one additional sensor (112, 114) to the additional sub node (118),

arranging the additional sub node (118) in communication with the main node (120),

transmitting data regarding the determined environmental condition in the at least one additional storm drain (102, 104) from the additional sub node (116, 118) to the main node (120),

transmitting data regarding the determined environmental condition outside the storm drain from the at least one external sensor (122, 124) arranged outside the storm drain (102, 104) to the main node (120),

determining by means of the main node (120), based on the determined environmental condition outside the storm (102, 104), an expected range for the determined environmental condition in the storm drain (102) and an expected range for the determined environmental condition in the at least one additional storm drain (104),

comparing by means of the main node (120), the determined environmental condition in the storm drain (102) and the determined environmental condition in the at least one additional storm drain (104) with the expected ranges respectively,

generating a signal by means of the main node (120) if the determined environmental condition in the storm drain (102) or the determined environmental condition in the at least one additional storm drain (104) is determined not to be included in the expected ranges respectively, wherein the signal at least being indicative of which storm drain (102, 104) has a determined environmental condition not included in its expected range.

14. Method according to claim 13, the method further comprising,
storing the signal in the main node (120) or transmitting the signal from the main node to the at least one remote resource (126, 127).

15. Use of the system (100) according to any one of claims 1 – 9 for monitoring an environmental condition in a storm drain (102, 104).