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## INDOOR AIR QUALITY MANAGEMENT APPARATUS AND METHOD

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### Abstract

An indoor air quality system is configured to improve indoor air quality conditions within a local environment of a building. The indoor air quality system operates according to a method that includes obtaining indoor air levels and operating one or more appliances to adjust the indoor air levels. The system includes one or more monitoring devices.

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## Background/Summary

PRIORITY CLAIM [0001] This application claims priority under 35 U.S.C. § 119(e) to PCT Application Serial No. US23/19693, filed Apr. 23, 2023 and U.S. Provisional Application Ser. No. 63/335,246 filed Apr. 27, 2022, which is expressly incorporated by reference herein.

### BACKGROUND

[0002] The present disclosure relates to air quality, and particularly to systems for improving air quality. More particularly, the present disclosure relates to systems for improving indoor air quality.

### SUMMARY

[0003] According to the present disclosure, a method of dehumidifying air within a local environment of a structure includes positioning a plurality of monitoring devices in the local environment of the structure. Each monitoring device of the plurality of monitoring devices being located in a corresponding room of the structure. The method may further include determining a room humidity level with each monitoring device in each room the structure where the monitoring devices are located. The method may further include calculating a total humidity level of the local environment based on each of the room humidity levels. The method may further include activating a dehumidification device to remove moisture from the air within the local environment of the structure when the total humidity level of the local environment is above a predetermined threshold.

[0004] According to another aspect of the present disclosure, a method of improving humidity levels within a local environment of a structure includes positioning a plurality of monitoring devices in the local environment of the structure. Each monitoring device of the plurality of monitoring devices being located in a corresponding room of the structure. The method may further include determining a room humidity level with each monitoring device in each room the structure where the monitoring devices are located. The method may further include calculating a total humidity level of the local environment based on each of the room humidity levels. The method may further include determining whether to activate or deactivate a dehumidification device to remove moisture from the air within the local environment of the structure based on the total humidity level of the local environment.

[0005] In illustrative embodiments, an air quality system for improving indoor air quality levels within a local environment of a building includes a plurality of monitoring devices with at least one monitoring device being positioned in separate rooms of the building. The system may further include a plurality of appliances including an exhaust fan, a supply fan, and a dehumidification unit. The method may further include a control system in communication with the plurality of monitoring devices and the plurality of appliances and configured to operate one or more of the appliances in response to signals from the plurality of monitoring devices. The control system is configured to: obtain outdoor air quality index data from an external data source, determine a room humidity level with each monitoring device in each room the structure where the monitoring devices are located, calculate a total humidity level of the local environment based on each of the room humidity levels, and determine whether to activate or deactivate a dehumidification device to remove moisture from the air within the local environment of the structure based on the total humidity level of the local environment and the outdoor air quality index data.

[0006] In some embodiments, the control system is configured to obtain an outdoor dew point from the outdoor air quality index data and calculate an indoor dew point from the total humidity level. In some embodiments, if the outdoor dew point is greater than the indoor dew point and the indoor

dew point is greater than an acceptable, predetermined threshold, the control system is configured to activate the exhaust and supply fans together with the dehumidification device to remove indoor pollutants and decrease humidity within the indoor environment at the same time.

[0007] Additional features of the present disclosure will become apparent to those skilled in the art upon consideration of illustrative embodiments exemplifying the best mode of carrying out the disclosure as presently perceived.

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## Description

### BRIEF DESCRIPTIONS OF THE DRAWINGS

[0008] The detailed description particularly refers to the accompanying figures in which:

[0009] FIG. 1 is a side elevation view of a building with portions removed to show that the building includes an indoor air quality system;

[0010] FIG. 2A is a portion of a flow chart describing operation of the indoor air quality system of FIG. 1;

[0011] FIG. 2B is another flow chart describing additional operations of the indoor air quality system of FIG. 1;

[0012] FIG. 3A is a portion of another flow chart describing operation of the indoor air quality system of FIG. 1;

[0013] FIG. 3B is another portion of the flow chart of FIG. 3A;

[0014] FIG. 4A is a portion of another flow chart describing operation of the indoor air quality system of FIG. 1; and

[0015] FIG. 4B is another portion of the flow chart of FIG. 4A.

### DETAILED DESCRIPTION

[0016] An indoor air quality (IAQ) system **10** for a building **100** includes a plurality of monitoring devices **102** and a plurality of air quality appliances or devices **106** connected to each of the monitoring devices **102** as shown in FIG. 1. The monitoring devices **102** are configured to sense and record IAQ data from an indoor environment **98** of the structure **100**. The IAQ data includes temperature, humidity and/or pollutant levels, such as TVOC, CO<sub>2</sub>, PM<sub>2.5</sub>. The IAQ data may be recorded on a local server/database **110** (also called a control system) included in the IAQ system **10**. The plurality of connected appliances **106** are operated based on the sensed IAQ data. In particular, the plurality of appliances **106** includes a dehumidification device **128** that is configured to adjust the humidity levels within the indoor environment **98** of the structure **100** in response to sensed humidity levels being outside a predetermined threshold or range.

[0017] The IAQ system **10** is also capable of obtaining outdoor air quality index (AQI) data external to the structure (e.g. weather, smoke, fog, temperature, humidity, dew point, and/or pollutant levels, such as TVOC, CO<sub>2</sub>, PM<sub>2.5</sub>) from various locations surrounding the structure **100** to compare with the IAQ data obtained within the structure **100**. The AQI data may be obtained from an external data source **113**. The connected appliances **106**, including the dehumidification device **128**, are then operated in response to the sensed IAQ data from the monitoring devices **102** and the AQI data from the external data source **113**. In some embodiments, the AQI data is calculated by and obtained from a government entity (e.g. the United States or Canada) such as the US National Oceanic and Atmospheric Administration (NOAA).

[0018] The local server/database **110** may be located in or around the structure **100** or may be located in a remote location to the structure **100**. The local server/database **110** may: i) analyze the IAQ data, ii) determine if all levels contained within IAQ data are within predefined threshold ranges, and iii) may recommend that the IAQ system **10** take certain steps (e.g., turn ON/OFF various appliances) to bring certain levels of the components within the predetermined threshold range or adjust the levels of the components based on the AQI data from the AQI data source **113**.

The IAQ system **10** can carry out these steps by controlling the operational mode (e.g., ON/OFF and/or the speed of the fan) of one or more appliances **106** contained within the operating environment. Once the IAQ system **10** has determined that the levels contained within the IAQ data are within predetermined threshold ranges that counteract the anticipated AQI data, the IAQ system **10** may instruct the appliances **106** to turn OFF or take further action in response to the AQI data. It should be understood in certain embodiments that some of the devices set forth above may be omitted. Additionally, in other embodiments, the IAQ system **10** may include additional devices and/or components. Reference is hereby made to U.S. patent application Ser. No. 17/298,362, filed May 28, 2021, and U.S. patent application Ser. No. 17/417,471, filed Jun. 23, 2021, each of which is incorporated by reference here in in their entirety.

[0019] The monitoring device **102** includes at least one sensor, which it uses to collect data about the local environment **98** of the structure **100**. Some or all of this IAQ data is then sent to the local server/database **110**, which processes and stores this data. If the local server/database **110** determines that one level contained within the IAQ data is out of the predetermined threshold range, then the IAQ system **10** may be configured to operate one or more of the appliances **106** to adjust the level. If the local server/database **110** determines that levels contained in the AQI data are outside of the predetermined threshold ranges, the IAQ system **10** may further operate one or more of the appliances **106** to bring indoor air levels within certain ranges in response to the AQI data. For example, if the AQI data indicates that outdoor levels will be in an unacceptable range at 1 PM, the IAQ system **10** may ventilate the local environment **98** of the structure **100** prior to 1 PM. In some embodiments, the IAQ system **10** may exceed a ventilation threshold to over-ventilate the structure **100** prior to 1 PM to minimize indoor air contaminants levels and to anticipate the ventilation system shutdown at 1 PM and the associated indoor air contaminants rise.

[0020] In one embodiment, the monitoring device **102** is or includes a plurality of sensors for monitoring the environment **98** as depicted in FIG. 1. In some embodiments, each sensor is the same and is configured to measure a plurality of different levels of pollutants and other characteristics of the air in the local environment **98** of the structure **100**. In some embodiments, one such sensor is located in each room of the structure **100** to provide data on air quality levels within each respective room. The data from each sensor are output to and collected by the local server/database **110**. The levels can be averaged among each room to determine an overall level for each pollutant and/or characteristic of the air in the structure **100** as a whole. User preferences or inputs may be made to the IAQ system **10** to manually weight certain contaminant levels to cause the IAQ system **10** to address that contaminant(s) ahead of others. Certain contaminants may be weighted automatically based on health hazards. In some embodiments, dimensions of each room are stored in local server/database **110** and a weight is given to the air quality levels determined in each room based on the total volume of air in each respective room of the structure **100**. In other embodiments, each sensor is different from one another and dedicated to measuring at least one specific pollutant. The monitoring device **102** can include one or more separate infrared (IR) sensors, one or more separate air pollutant sensors, one or more motion sensors, and one or more separate humidity/temperature sensors, with each sensor being positioned in different parts or rooms of the structure **100**.

[0021] Applying weighted humidity values can optimize operation of the dehumidification device **128** to account for short termed and/or localized high-humidity events such as showering or cooking. The local database/server **110** may weight the humidity values sensed by the monitoring device **102** in rooms of the building **100** such as bathrooms and kitchens to account for these short and/or localized high-humidity events. In one example, structure **100** includes a single bathroom and the volume of air within the bathroom is about 10% of the total volume of the environment **98**. Prior to a hot shower event, the humidity in the bathroom is equal to about 50% as sensed by a monitoring device **102** in the bathroom. The shower event lasts 10 minutes and the humidity of the bathroom increases to 90% during the shower event. In this situation, the local database/server **110**

can determine that a short, localized, high-humidity event has occurred in the bathroom by determining the humidity values of every other room where there is a monitoring device **102** present. In such a situation, the high humidity value sensed in the bathroom could increase the total humidity value of the structure above a threshold if all rooms were weighted equally. Under normal circumstances the local database/server **110** would activate the dehumidification device to dehumidify the entire environment **98**. However, in the illustrative embodiment, the local database/server **110** is configured to recognize when a short, localized, high-humidity event has occurred in the bathroom and can ignore the humidity value received from that room when calculating the total humidity value of the environment **98**. Thus, the dehumidification unit **128** is not activated during some short, localized, high-humidity events even if the total humidity value of the environment **98** calculated by local database/server **110** is above the threshold. More than one room in the building **100** can have a high-humidity event at the same time and the adjustment to the calculation of the total humidity value within environment **98** can be made taking all high-humidity events into account. In some embodiments, the local server **110** can determine whether or not an exhaust fan associated with the room in which the event has occurred is activated or not. The system **10** may activate the exhaust fan and/or the dehumidification unit **128** if it is determined that the shower occupant has forgotten to activate the exhaust fan.

[0022] In one example, the local database/server **110** is configured to monitor a rate of change of the humidity level sensed by the monitoring device **102** in each room or in selected rooms such as bathrooms and kitchens. The local/database server **110** can determine when there is a short, localized, high-humidity event using the rate of change of the humidity level. In some embodiments, the rate of change that indicates a short, localized, high-humidity event is a humidity level increase of at least 1% per minute. In some embodiments, the rate of change that indicates a short, localized, high-humidity event is a humidity level increase of at least 2% per minute. In some embodiments, the rate of change that indicates a short, localized, high-humidity event is a humidity level increase of at least 3% per minute. In some embodiments, the rate of change that indicates a short, localized, high-humidity event is a humidity level increase of at least 4% per minute. In some embodiments, the rate of change that indicates a short, localized, high-humidity event is a humidity level increase of at least 5% per minute. In some embodiments, the rate of change that indicates a short, localized, high-humidity event is a humidity level increase of at least 6% per minute. In some embodiments, the rate of change that indicates a short, localized, high-humidity event is a humidity level increase of at least 7% per minute. In some embodiments, the rate of change that indicates a short, localized, high-humidity event is a humidity level increase of at least 8% per minute. In some embodiments, the rate of change that indicates a short, localized, high-humidity event is a humidity level increase of at least 9% per minute. In some embodiments, the rate of change that indicates a short, localized, high-humidity event is a humidity level increase of at least 10% per minute. In another example, humidity readings in a bathroom can be routinely ignored due to the unreliability of readings introduced by showering.

[0023] The AQI data source **113** may include distributed external sensors, weather pattern data, historical air quality databases, air quality prediction databases, and other information about the air that is exterior to the structure **100**. For example, one external sensor may be located in the outside air supply duct to measure contaminant levels being brought into the local environment **98**. The data source **113** may include a prediction table that is based on information derived from current and historical data collected from: i) exterior local/regional/national sensors (e.g. dew point, temperature, air pollutants), ii) sensors installed in other structures, iii) weather information, iv) electricity costs, and v) other similar types of data. The data contained within the data source **113** can be accessed by a combination of the national database **112** and the local server/database **110**. This data can be utilized to help make predictions when levels of the components of both indoor air and outdoor air will be deemed to be out of predetermined threshold ranges and facilitate a

determination of which corrective measures to take (e.g. operate one or more exhaust fans to exhaust indoor air and/or operate one or more supply fans to bring in outdoor air (also known as fresh air)). The data source **113** can be utilized to maximize the quality of the air contained within the structure **100** based on predictions about the exterior environmental conditions. In some situations, alerts from a National/Regional weather surveillance service may be input and stored in the local server/database **110** and utilized when operating the IAQ system **10**.

[0024] A user may be required to enter their zip code into the IAQ system **10**. The IAQ system **10** may use this zip code to determine the closest AQI weather station and allow the user to change the default. The zip code may also be used to select the default (AQI vs. Humidity).

The IAQ system **10** may consider climate zones and determine by climate zone what will be the default condition. For instance, in the southern areas of the United States the default preference may be humidity while in western United States areas the default preference may be AQI. The user may have the ability to change the default and their preference if so desired.

[0025] If cost are associated with obtaining AQI data from data source **113**, the IAQ system **10** may query all existing systems in the same or similar zip code. In this case, only one IAQ system **10** within that zip code may obtain the AQI data and the other IAQ systems **10** may obtain the AQI data from the first IAQ system **10**, thus minimizing the number of calls and associated costs.

[0026] The one or more appliances **106** used with the IAQ system **10** can include any heating, ventilation, and air conditioning device or any device that controls/changes the air within local environment **98** (i.e. air purifiers, heaters, swamp coolers, humidifiers, etc.). In the illustrative embodiment, the appliances **106** used with the IAQ system **10** include one or more exhaust fans (i.e. bathroom fan(s) **120** or range hood(s) **122**), a coupled or decoupled supply fan **124** (which can, optionally, be connected to or part of a central unit **104**), an energy/heat recovery device **126**, the dehumidification device **128**, an air purifier **130**, and/or a humidification device **132** as shown in FIG. **1**. The one or more exhaust fans **120** are configured to remove air from the local environment to outside the structure **100** for ventilation purposes. The supply fan **124** is part of a fresh air system with at least one port **125** open to the ambient environment outside the structure **100**, allowing the supply **124** to draw outdoor air into the indoor operating environment **98** of the building structure **100**. The supply fan **124** is configured to circulate fresh air throughout the structure **100** via a plurality of ducts and vents/dampers. The port may include a damper (not depicted) to selectively open when fresh air is desired to be drawn into the local environment as explained in greater detail below. In an alternative embodiment, the supply fan **124** is not connected to a central unit **104**, but instead simply draws outdoor air into the particular location of the building structure **100** in which the fresh air system is located. The supply fan **124** may also include an outlet port for exhaust purposes. The energy/heat recovery device **126** is coupled to one or more air inlet/outlet flows and is configured to exchange heat and/or energy between an intake airflow flowing into the structure **100** and an exhaust airflow flowing out of the structure **100** to minimize energy/heat losses as a result of operating the IAQ system **10**. The dehumidification device **128** is configured to decrease relative humidity within the local environment **98**. The humidification device **132** is configured to increase the relative humidity within the local environment **98**. The air purification device **130** is configured to decrease the particles matter content of the air and/or the gaseous pollutants content of the air within the local environment **98**. Each of the devices is activated or deactivated in response to the sensed indoor air condition levels from the monitoring devices **102**

and the outdoor AQI data from the AQI data source **113**, as explained in each of the scenarios described below, in order to optimize the IAQ of environment **98**.

[0027] A first schematic flow chart **200** describing the operation of the IAQ system **10** is shown in FIG. **2**. In the flow chart of FIG. **2**, the IAQ system **10** includes one or more exhaust fans **120/122** and a coupled supply fan **124** with a make-up air damper (MUAD). “Make-up air” is outdoor air brought into the building structure **100** to replace exhausted air and maintain an appropriate air

pressure balance between the indoor and outdoor environments. A first step **210** includes determining whether indoor dew point is equal to outdoor dew point levels. This may be assumed or sensed by the monitoring units **102** and by consulting the data source **113** or data provided by one or more appliances **106**.

[0028] The following ranges of values will be used to indicate good/medium/bad ranges of values and better/worse values as discussed below:

TABLE-US-00001 Indoor Air Outdoor Air Quality Level (IAQ) Quality Index (AQI) Humidity  
Good 0-40 0-100 40-60% Medium 41-80 101-150 20-39% or 61-80% Bad 81-100 151+ <20%  
or >80%

[0029] The following ranges will be used to indicate better, worse, and same conditions described below. Better means greater than 10%. Worse means less than 10%. Same means within 10%. In other embodiments, a different range may be used (i.e. 5%, 15%, 20%, etc.).

[0030] If indoor dew point levels are equal to outdoor dew point levels, the process **200** proceeds to a first ventilation sub-process **220** where only exhaust and supply fans are operated/activated (fan state=1) to vent the local environment **98** depending on air quality levels of both the local environment and the outdoor environment. At a first step **221**, the local database/server **110** determines whether the IAQ data from the monitoring devices **102** is greater than a second IAQ threshold (i.e. a bad IAQ). If the IAQ data from the monitoring devices **102** is greater than the second IAQ threshold, the exhaust and supply fans are activated to ventilate the local environment **98**. If the IAQ data from the monitoring devices **102** is not greater than the second IAQ threshold, the process **220** proceeds to step **222** where the local database/server **110** determines whether the IAQ data from the monitoring devices **102** is greater than a first IAQ threshold (i.e. a medium IAQ). If the IAQ data from the monitoring devices **102** is not greater than the first IAQ threshold, the exhaust and supply fans are not operated (i.e. fan state=0). If the IAQ data from the monitoring devices **102** is greater than the first IAQ threshold, the process **220** proceeds to a step **223** where the database/server **110** determines whether the outdoor AQI data is greater than a second AQI threshold (i.e. a bad AQI). If the outdoor AQI data is greater than the second AQI threshold, the exhaust and supply fans are not operated. If the outdoor AQI data is not greater than the second AQI threshold, the exhaust and supply fans are operated. The exhaust and supply fans may be modulated depending on if more or less ventilation or other air conditioning action is needed/desired.

[0031] Returning to decision step **210**, if the indoor dew point is not equal to the outdoor dew point, the process **200** proceeds to a second ventilation sub-process **230** which considers user preference and humidity when determining when to operate the fans and/or other devices. At a first step **231**, the user may provide an input into the system **10** to indicate a preference for humidity control (sub-process **240**) or IAQ control (sub-process **250**). The dehumidification device **128** can be used in either sub-process **240**, **250**.

[0032] Sub-process **240** includes a decision step **241** where the database/server **110** determines whether the indoor dew point is greater than the outdoor dew point. If the indoor dew point is greater than the outdoor dew point, the exhaust and supply fans are operated to ventilate the local environment **98** to exchange the less humid outdoor air with the more humid indoor air. If the indoor dew point is not greater than the outdoor dew point, the exhaust and supply fans may not be operated.

[0033] The dehumidification device **128** may also be operated to remove moisture from the indoor air. For example, if the indoor humidity level is greater than a predetermined threshold, the dehumidification device **128** may be is operated to reduce the humidity level within the indoor environment **98**. This operation can be performed with or without regard to the outdoor dew point obtained by the external data source **113**. For example, even if the outdoor dew point is greater than the indoor dew point and the indoor dew point is greater than an acceptable threshold, the exhaust and supply fans may be operated together with the dehumidification device **128** to remove indoor

pollutants and decrease humidity within the indoor environment at the same time. In such an instance, indoor pollutant levels are above a threshold pollutant level, indoor humidity is above a threshold humidity level, and outdoor dew point is greater than indoor dew point. Other systems without a dehumidification device **128** may determine that the exhaust and supply fans should not be activated in this situation since this would result in high-humidity outdoor air being brought into the indoor environment **98** which itself already has a humidity above an acceptable level. However, in the illustrative embodiment, the IAQ system **10** is configured to activate the exhaust and supply fans and the dehumidification device to improve pollution levels and humidity levels within the indoor environment at the same time.

[0034] The dehumidification device **128** may include its own intake port or may be coupled to the same intake port **125** as the supply fan **124**. One or more valves (not shown) may be coupled to the ducts interconnecting the intake port **125** and the supply fan **124** and the dehumidification device **128** to control the flow of air therebetween as shown in FIG. **1**. The valve(s) can be controlled by the local database/server **110** in response to sensed IAQ data and external AQI data.

[0035] Sub-process **250** includes a step **251** where the local database/server **110** determines whether the IAQ data from the monitoring devices **102** is greater than the first IAQ threshold. If the IAQ data from the monitoring devices **102** is not greater than the first IAQ threshold, the sub-process proceeds to a step **252** where the local database/server **110** determines whether the AQI data is greater than a first AQI threshold (i.e. a medium/bad AQI value). If the AQI data is greater than the first AQI threshold, the exhaust and supply fans are not operated. If the AQI data is not greater than the first AQI threshold, the sub-process proceeds to a step **253** where the local database/server determines whether indoor dew point is greater than outdoor dew point. If indoor dew point is greater than outdoor dew point, the exhaust and supply fans are operated. The dehumidification device **128** may also be operated if indoor dew point is greater than outdoor dew point. If indoor dew point is not greater than outdoor dew point, the exhaust and supply fans are not operated.

[0036] The dehumidification device **128** may also be operated if indoor dew point is less than outdoor dew point while the exhaust and supply fans are operated as described above. Thus, in this situation, IAQ is greater than the first IAQ threshold, AQI is less than the first AQI threshold, indoor dew point is less than outdoor dew point, and the exhaust and supply fans are activated while the dehumidification unit is being operated.

[0037] If the IAQ data from the monitoring devices **102** is greater than the first IAQ threshold, the sub-process proceeds to a step **254** where the local database/server **110** determines whether the IAQ data from the monitoring devices **102** is greater than the second IAQ threshold. If the IAQ data from the monitoring devices **102** is greater than the second IAQ threshold, the sub-process **250** proceeds to step **255** where the local database/server **110** determines whether the AQI data is greater than the second AQI threshold. If the IAQ data from the monitoring devices **102** is not greater than the second IAQ threshold, the sub-process **250** proceeds to step **256** where the local database/server **110** determines whether the AQI data is greater than the first AQI threshold.

[0038] From step **255**, if the AQI data is greater than the second AQI threshold, the exhaust and supply fans are operated. If the AQI data is not greater than the second AQI threshold, the sub-process **250** proceeds to step **257** where the local database/server **110** determines whether indoor dew point is greater than outdoor dew point. If indoor dew point is greater than outdoor dew point, the exhaust and supply fans are operated. If indoor dew point is not greater than outdoor dew point, the exhaust and supply fans are not operated.

[0039] From step **256**, if the AQI data is not greater than the first AQI threshold, the exhaust and supply fans are operated. If the AQI data is greater than the first AQI threshold, the sub-process **250** proceeds to a step **258** where the local database/server **110** determines whether the AQI data is greater than the second AQI threshold. If the AQI data is greater than the second AQI threshold, the exhaust and supply fans are not operated. If the AQI data is not greater than the second AQI



threshold, the sub-process **250** proceeds to step **259** where the local database/server **110** determines whether indoor dew point is greater than outdoor dew point. If indoor dew point is greater than outdoor dew point, the exhaust and supply fans are operated. If indoor dew point is not greater than outdoor dew point, the exhaust and supply fans are not operated.

[0040] The dehumidification device **128** may also be operated without regard to the decision at step **259**. For example, in one situation, IAQ is greater than the first IAQ threshold, IAQ is less than the second IAQ threshold, AQI is greater than the first AQI threshold, AQI is less than the second AQI threshold, indoor dew point is less than outdoor dew point, and the exhaust and supply fans are activated while the dehumidification device **128** is being operated. In another situation, IAQ is greater than the first IAQ threshold, IAQ is greater than the second IAQ threshold, AQI is less than the second AQI threshold, indoor dew point is less than outdoor dew point, and the exhaust and supply fans are activated while the dehumidification device **128** is being operated.

[0041] A second schematic flow chart **300** describing the operation of the IAQ system **10** is shown in FIG. **3**. In the flow chart of FIG. **3**, the IAQ system **10** includes one or more exhaust fans **120/122** and a de-coupled supply fan **124**. A first step **310** includes determining whether indoor dew point is equal to outdoor dew point levels. This may be assumed or sensed by the monitoring units **102** and by consulting the data source **113**. The same good/medium/bad ranges discussed above apply to process **300**. The same ranges for better/worse and same apply to process **300**.

[0042] If indoor dew point levels are equal to outdoor dew point levels, the process **300** proceeds to a first ventilation sub-process **320** where only exhaust and supply fans are operated (fan state=1) to vent the local environment **98** depending on air quality levels of both the local environment and the outdoor environment. At a first step **321**, the local database/server **110** determines whether the IAQ data from the monitoring devices **102** is greater than a second IAQ threshold (i.e. a bad IAQ). If the IAQ data from the monitoring devices **102** is not greater than the second IAQ threshold, the process **320** proceeds to step **322** where the local database/server **110** determines whether the IAQ data from the monitoring devices **102** is greater than a first IAQ threshold (i.e. a medium IAQ). If the IAQ data from the monitoring devices **102** is greater than the second IAQ threshold, the sub-process **320** proceeds to a step **323** where the local database/server **110** determines whether the AQI data is greater than the second AQI threshold.

[0043] At step **322**, if the IAQ data from the monitoring devices **102** is not greater than the first IAQ threshold, the exhaust and supply fans are not operated (i.e. fan state=0). If the IAQ data from the monitoring devices **102** is greater than the first IAQ threshold, the sub-process **320** proceeds to a step **324** where the local database/server **110** determines if the AQI data is greater than the first AQI threshold. If the AQI data is greater than the first AQI threshold, the exhaust and supply fans are not operated. If the AQI data is not greater than the first AQI threshold, the exhaust and supply fans are operated.

[0044] At step **323**, if the outdoor AQI data is greater than the second AQI threshold, the exhaust and supply fans are not operated. If the outdoor AQI data is not greater than the second AQI threshold, the exhaust and supply fans are operated.

[0045] Returning to decision step **310**, if the indoor dew point is not equal to the outdoor dew point, the process **300** proceeds to a second ventilation sub-process **330** which considers user preference and humidity when determining when to operate the fans and/or other devices. At a first step **331**, the user may provide an input into the system **10** to indicate a preference for humidity control (sub-process **240**) or IAQ control (sub-process **250**). Sub-process **340** and sub-process **350** are the same as sub-process **240** and sub-process **250**, respectively. Accordingly, the disclosure above is incorporated by reference herein. Similar reference numbers in the **300** series are used to indicate steps common between sub-processes **240**, **250** and sub-processes **340**, **350**.

[0046] A third schematic flow chart **400** describing the operation of the IAQ system **10** is shown in FIG. **4**. In the flow chart of FIG. **4**, the IAQ system **10** includes one or more exhaust fans **120/122**, a coupled or de-coupled supply fan **124** and the energy/heat recovery device **126**. The IAQ system

further includes a notification device **114** which may be a fixed panel or user interface in the structure **100** or a mobile device such as a smart-phone, tablet, computer, etc. The notification device **114** is configured to notify a user when certain conditions are present—namely when outdoor AQI data is greater than the first or second AQI data thresholds. This provides the user with a notification that the IAQ system **10** is not operating and a reason for why the IAQ system **10** is not operating. In other embodiments, any alert or message may be output by the IAQ system **10** following an action. For example, the alert may inform the user of a status of the IAQ system **10**. [0047] A first step **410** includes determining whether indoor dew point is equal to outdoor dew point levels. This may be assumed or sensed by the monitoring units **102** and by consulting the data source **113**. The same good/medium/bad ranges discussed above apply to process **400**. The same ranges for better/worse and same apply to process **400**.

[0048] If indoor dew point levels are equal to outdoor dew point levels, the process **400** proceeds to a first ventilation sub-process **420** where only exhaust and supply fans are operated (fan state=1) to vent the local environment **98** depending on air quality levels of both the local environment and the outdoor environment. If the indoor dew point is not equal to the outdoor dew point, the process **400** proceeds to a second ventilation sub-process **430** which considers user preference and humidity when determining when to operate the fans and/or other devices. At a first step **431**, the user may provide an input into the system **10** to indicate a preference for humidity control (sub-process **440**) or IAQ control (sub-process **450**).

[0049] At a first step **421** of sub-process **420**, the local database/server **110** determines whether the IAQ data from the monitoring devices **102** is greater than a second IAQ threshold (i.e. a bad IAQ). If the IAQ data from the monitoring devices **102** is not greater than the second IAQ threshold, the process **420** proceeds to step **422** where the local database/server **110** determines whether the IAQ data from the monitoring devices **102** is greater than a first IAQ threshold (i.e. a medium IAQ). If the IAQ data from the monitoring devices **102** is greater than the second IAQ threshold, the sub-process **420** proceeds to a step **423** where the local database/server **110** determines whether the AQI data is greater than the second AQI threshold.

[0050] At step **422**, if the IAQ data from the monitoring devices **102** is not greater than the first IAQ threshold, the exhaust and supply fans are not operated (i.e. fan state=0). If the IAQ data from the monitoring devices **102** is greater than the first IAQ threshold, the sub-process **420** proceeds to a step **424** where the local database/server **110** determines if the AQI data is greater than the first AQI threshold. If the AQI data is greater than the first AQI threshold, the exhaust and supply fans are not operated and the notification is output by the local database/server **110** and displayed on the notification device **114**. If the AQI data is not greater than the first AQI threshold, the exhaust and supply fans are operated.

[0051] At step **423**, if the outdoor AQI data is greater than the second AQI threshold, the exhaust and supply fans are not operated and the notification is output by the local database/server **110** and displayed on the notification device **114**. If the outdoor AQI data is not greater than the second AQI threshold, the exhaust and supply fans are operated.

[0052] Sub-process **440** includes a decision step **441** where the database/server **110** determines whether the indoor dew point is greater than the outdoor dew point. If the indoor dew point is greater than the outdoor dew point, the exhaust and supply fans are operated to ventilate the local environment **98** to exchange the less humid outdoor air with the more humid indoor air. The dehumidification device **128** may also be operated to remove moisture from the indoor air. If the indoor dew point is not greater than the outdoor dew point, the sub-process proceeds to a step **442** where the local database/server **110** determines if outdoor AQI data is greater than the first AQI threshold. If the outdoor AQI data is greater than the first AQI threshold the exhaust and supply fans are not operated and the notification is output by the local database/server **110** and displayed on the notification device **114**. If the outdoor AQI data is not greater than the first AQI threshold the exhaust and supply fans are not operated and no notification is output by the local

database/server **110** or displayed on the notification device **114**.

[0053] Sub-process **450** includes a step **451** where the local database/server **110** determines whether the IAQ data from the monitoring devices **102** is greater than the first IAQ threshold. If the IAQ data from the monitoring devices **102** is not greater than the first IAQ threshold, the sub-process proceeds to a step **452** where the local database/server **110** determines whether the AQI data is greater than a first AQI threshold (i.e. a medium/bad AQI value). If the AQI data is greater than the first AQI threshold, the exhaust and supply fans are not operated and the notification is output by the local database/server **110** and displayed on the notification device **114**. If the AQI data is not greater than the first AQI threshold, the sub-process proceeds to a step **453** where the local database/server determines whether indoor dew point is greater than outdoor dew point. If indoor dew point is greater than outdoor dew point, the exhaust and supply fans are operated. The dehumidification device **128** may also be operated if indoor dew point is greater than outdoor dew point. If indoor dew point is not greater than outdoor dew point, the exhaust and supply fans may not be operated.

[0054] If the IAQ data from the monitoring devices **102** is greater than the first IAQ threshold, the sub-process proceeds to a step **454** where the local database/server **110** determines whether the IAQ data from the monitoring devices **102** is greater than the second IAQ threshold. If the IAQ data from the monitoring devices **102** is greater than the second IAQ threshold, the sub-process **450** proceeds to step **455** where the local database/server **110** determines whether the AQI data is greater than the second AQI threshold. If the IAQ data from the monitoring devices **102** is not greater than the second IAQ threshold, the sub-process **450** proceeds to step **456** where the local database/server **110** determines whether the AQI data is greater than the first AQI threshold.

[0055] From step **455**, if the AQI data is greater than the second AQI threshold, the exhaust and supply fans are operated. If the AQI data is not greater than the second AQI threshold, the sub-process **450** proceeds to step **457** where the local database/server **110** determines whether indoor dew point is greater than outdoor dew point. If indoor dew point is greater than outdoor dew point, the exhaust and supply fans are operated. If indoor dew point is not greater than outdoor dew point, the exhaust and supply fans are not operated.

[0056] From step **456**, if the AQI data is not greater than the first AQI threshold, the exhaust and supply fans are operated. If the AQI data is greater than the first AQI threshold, the sub-process **450** proceeds to a step **458** where the local database/server **110** determines whether the AQI data is greater than the second AQI threshold. If the AQI data is greater than the second AQI threshold, the exhaust and supply fans are not operated and the notification is output by the local database/server **110** and displayed on the notification device **114**. If the AQI data is not greater than the second AQI threshold, the sub-process **450** proceeds to step **459** where the local database/server **110** determines whether indoor dew point is greater than outdoor dew point. If indoor dew point is greater than outdoor dew point, the exhaust and supply fans are operated. If indoor dew point is not greater than outdoor dew point, the exhaust and supply fans may not be operated.

[0057] According to one aspect of the present disclosure, the disclosed system can be implemented using a computer system in response to a processor executing one or more sequences of one or more instructions contained in memory. Such instructions may be read into memory from another machine-readable medium, such as data storage device. Execution of the sequences of instructions contained in main memory causes the processor to perform the process steps described herein. In alternative implementations, hard-wired circuitry may be used in place of or in combination with software instructions to implement various implementations of the present disclosure. Thus, implementations of the present disclosure are not limited to any specific combination of hardware circuitry and software.

[0058] Issues related to indoor air quality may be exasperated by outdoor air quality. Forest fires, smog, pollen and other external factors can all affect outdoor air quality. The IAQ system includes a database of ongoing outdoor air quality data including but not limited to weather, particulates,

outdoor temperature, and outdoor humidity. The present disclosure integrates an outdoor weather API so that the system can make better ventilation decisions based upon both indoor as well as outdoor conditions in combination. Outdoor Air Quality Index (AQI) information may be displayed in on a user interface. References to outdoor AQI health issues including but not limited to irritated eyes, coughing, as well as risks to health may also be displayed on the user interface.

[0059] A user of the IAQ system may input their home zip code during initial setting up of the IAQ. This input may be used when accessing the weather API to define the nearest weather station and associated AQI data. The user may also have the option of selecting an alternate available weather station from the API within their zip code. The IAQ system may have a default selection for humidity or outdoor AQI based upon zip code/climate zone.

[0060] The AQI or elements thereof could be used to forecast/predict future events and used in the system algorithm. For example, if high PM2.5 is forecasted for the upcoming day from the weather API, the system algorithm may call for a longer ventilation period ahead of the predicted problematic forecast. The overall AQI score (numeric value of several constituents (CO, NO2, O3, PM2.5, PM10, NO2, SO2) and outdoor humidity/temperature may be used to simplify the algorithm. In other embodiments, one or more individual outdoor AQI constituents may be utilized independently instead of the overall AQI score to further improve the precision of the system algorithm. Operation of the IAQ system **10** may consider energy costs, in some embodiments.

[0061] While the present disclosure describes various exemplary embodiments, the disclosure is not so limited. To the contrary, the disclosure is intended to cover various modifications, uses, adaptations, and equivalent arrangements based on the principles disclosed. Further, this disclosure is intended to cover such departures from the present disclosure as come within at least the known or customary practice within the art to which it pertains. It is envisioned that those skilled in the art may devise various modifications and equivalent structures and functions without departing from the spirit and scope of the disclosure as recited in the following claims.

## Claims

1. A method of dehumidifying air within a local environment of a structure, the method comprising placing a plurality of monitoring devices in the local environment of the structure comprised of one or more rooms of the structure, each monitoring device of the plurality of monitoring devices being located in one of the one or more rooms, determining a room humidity level for each of the one or more rooms with the monitoring device located in the corresponding one of the one or more rooms, weighting the room humidity level determined for each of the one or more rooms where high-humidity events take place, including (i) determining that a first room of the local environment has a first humidity level within an acceptable range and (ii) determining that a second room of the local environment has a second humidity level outside of the acceptable range, calculating a total humidity level of the local environment based on the room humidity levels of each of the one or more rooms, wherein calculating the total humidity level includes averaging each sensed humidity level in the local environment and activating a dehumidification device to remove moisture from the air within at least some of the one or more rooms when (i) the total humidity level is above a predetermined threshold, and (ii) it is determined there are no localized, high humidity events in the local environment.

2. (canceled)

3. The method of claim 1, further including activating a local exhaust fan in communication with the second room to remove moisture from the second room.

4. (canceled)

5. The method of claim 1, further comprising manually entering user preferences to adjust the weighting of the room humidity level determined for each of the one or more rooms.

6. The method of claim 1, further comprising determining that a high-humidity event has occurred

in a first room of the structure and adjusting the room humidity value of the first room prior to calculating the total humidity level of the local environment.

**7.** The method of claim 1, further comprising obtaining outdoor air quality index data and wherein the dehumidification device is activated to adjust at least one room humidity value based, at least in part, on the outdoor air quality index data.

**8.** The method of claim 7, wherein if an outdoor dew point determined by the monitoring devices is greater than an indoor dew point included in the outdoor air quality index data, and the indoor dew point is greater than an acceptable, predetermined threshold, the method further includes activating exhaust and supply fans together with the dehumidification device to remove indoor pollutants and decrease humidity within the indoor environment at the same time.

**9.** A method of improving humidity levels within a local environment of a structure, the method comprising placing a plurality of monitoring devices in the local environment of the structure comprised of one or more rooms of the structure, each monitoring device of the plurality of monitoring devices being located in one of the one or more rooms, determining a room humidity level for each of the one or more rooms with the monitoring device located in the corresponding one of the one or more rooms, calculating a total humidity level of the local environment based on the room humidity levels of each of the one or more rooms, obtaining outdoor air quality index data and wherein the dehumidification device is activated to adjust at least one room humidity value based, at least in part, on the outdoor air quality index data, obtaining an outdoor dew point from the outdoor air quality index data and calculating an indoor dew point from the total humidity level, determining whether to activate or deactivate a dehumidification device to remove moisture from the air within one or more of the one or more rooms based on the total humidity level, wherein the dehumidification device is activated to adjust at least one room humidity value based, at least in part, on the outdoor air quality index data, and determining to activate an exhaust fan and a supply fan together with the dehumidification device (i) if the outdoor dew point is greater than the indoor dew point and (ii) the indoor dew point is greater than an acceptable, predetermined threshold, to remove indoor pollutants and decrease humidity within the indoor environment at the same time, wherein the dehumidification device is not activated if the outdoor dew point is within 10% of the indoor dew point.

**10.** (canceled)

**11.** (canceled)

**12.** (canceled)

**13.** (canceled)

**14.** The method of claim 9, further comprising weighting the room humidity level determined for each of the one or more rooms.

**15.** The method of claim 14, wherein weighting the room humidity level includes determining that a first room of the local environment has a first humidity level within an acceptable range and determining that a second room of the local environment has a second humidity level outside of an acceptable range, and the method further includes activating a local exhaust fan in communication with the second room to remove moisture from the second room.

**16.** (canceled)

**17.** The method of claim 14, further comprising manually entering user preferences to adjust the weighting of the room humidity level determined for each of the one or more rooms.

**18.** The method of claim 9, further comprising determining that a high-humidity event has occurred in a first room of the structure and adjusting the room humidity value of the first room prior to calculating the total humidity level of the local environment.

**19.** (canceled)

**20.** (canceled)

**21.** A method of improving humidity levels within a local environment of a structure, the method comprising placing a plurality of monitoring devices in the local environment of the structure

comprised of one or more rooms of the structure, each monitoring device of the plurality of monitoring devices being located in one of the one or more rooms, determining a room humidity level for each of the one or more rooms with the monitoring device located in the corresponding one of the one or more rooms, calculating a total humidity level of the local environment based on the room humidity levels of each of the one or more rooms, obtaining outdoor air quality index data and wherein the dehumidification device is activated to adjust at least one room humidity value based, at least in part, on the outdoor air quality index data, obtaining an outdoor dew point from the outdoor air quality index data and calculating an indoor dew point from the total humidity level, determining whether to activate or deactivate a dehumidification device to remove moisture from the air within one or more of the one or more rooms based on the total humidity level, wherein the dehumidification device is activated to adjust at least one room humidity value based, at least in part, on the outdoor air quality index data, and determining to activate an exhaust fan and a supply fan together with the dehumidification device (i) if the outdoor dew point is greater than the indoor dew point and (ii) the indoor dew point is greater than an acceptable, predetermined threshold, to remove indoor pollutants and decrease humidity within the indoor environment at the same time wherein the exhaust and supply fans are not operated if the indoor dew point is less than the outdoor dew point.

**22.** A method of improving humidity levels within a local environment of a structure, the method comprising placing a plurality of monitoring devices in the local environment of the structure comprised of one or more rooms of the structure, each monitoring device of the plurality of monitoring devices being located in one of the one or more rooms, determining a room humidity level for each of the one or more rooms with the monitoring device located in the corresponding one of the one or more rooms, weighting the room humidity level determined for each of the one or more rooms, activating a local exhaust fan in communication with a second room of the local environment to remove moisture from the second room when (i) a first room of the local environment has a first humidity level within an acceptable range and (ii) the second room has a second humidity level outside of the acceptable range, calculating a total humidity level of the local environment based on the room humidity levels of each of the one or more rooms, wherein calculating the total humidity level includes averaging each sensed humidity level in the local environment, and determining whether to activate or deactivate a dehumidification device to remove moisture from the air within one or more of the one or more rooms based on the total humidity level, and activating the dehumidification device only when the total humidity level is above the predetermined threshold and it is determined that there are no localized, high humidity events in in the local environment.

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