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International Journal of Advanced Electrical and Electronics Engineering

ISSN: 2278-8948

Volume 13 Issue 01, 2024

A Smart Sanitary Waste-Management Node

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Peer Review Information

Submission: 15 Jan 2024
Revision: 11 Feb 2024
Acceptance: 09 March 2024

Keywords

Smart Waste Management, Internet of Things, Gas Sensing, Waste Segregation, ESP8266, Sanitation, Bin Monitoring, Sensor Selectivity, Exposure Limits.

Abstract

This paper reports an Internet-of-Things node for sanitary waste bins, comprising a gas sensor, a temperature and humidity sensor and an ESP8266-based controller which drives an exhaust fan and an audible alarm and publishes bin conditions to a mobile dashboard. The node's architecture, sensor response relations and alerting path are documented, and the operating principle of odour and decomposition monitoring in enclosed waste containers is formalised. The paper then audits the sorting claim that the project title carries, and reports three findings. First, the documented block diagram contains gas, temperature and humidity sensors driving a fan, an alarm and a mobile application; it contains no servo motors, no bin-selection mechanism, no tipping actuator and no fill-level sensor, so the automatic segregation and disposal functions described in the text are not evidenced in the hardware as documented. Second, gas and humidity sensing can in principle separate wet organic waste from dry waste, but carries no information capable of distinguishing metal, plastic and glass, the categories the project's own problem statement sets out, so the sensor set is not sufficient for the material sorting claimed regardless of implementation. Third, no measurement of any kind was recorded: no gas concentration, no classification accuracy, no fill level and no alert latency, so the system's performance is entirely indeterminate and no figure is reported. This revision adds a quantitative dimension to the second finding. The gases that matter in sanitary waste are hydrogen sulphide and ammonia, which become a health concern at single-figure parts per million and are perceptible far below that, whereas the fitted device's stated detection span begins at 200 ppm for a different target gas; the sensor is therefore mismatched to the application by roughly two orders of magnitude in range as well as in selectivity. The ventilation relations are also evaluated at bin scale, showing that dilution is fast and that the binding question is the steady-state balance against generation rate, which was not measured. Substantial passages of the source material describing pipeline leak detection and oil-level monitoring with a valve-closing relay are identified as belonging to a different project and excluded. A measurement plan and a corrected scope statement are given.

Nomenclature

Symbol	Meaning
θ	Volumetric water content (m^3/m^3)

θ~FC, θ~PWP	Water content at field capacity and at permanent wilting point
AWC	Available water capacity, the difference between the two (m^3/m^3)
θ~trig	Water content at which irrigation is triggered
p	Allowable depletion fraction before irrigation
Z_r	Root-zone depth (mm)
d, A, V	Refill depth (mm), irrigated area (m^2) and water volume (m^3)
V_{base}, V_{IoT}	Water volume used by the baseline practice and by the system
S	Water saving (%)
ADC	Raw analogue reading returned by the moisture probe
T_a, RH	Air temperature (degrees Celsius) and relative humidity (%)
ET_0, ET_c, K_c	Reference and crop evapotranspiration (mm/day) and crop coefficient

Introduction

Municipal solid waste management is limited less by collection capacity than by information: bins are emptied on fixed schedules rather than on need, so some overflow while others are collected empty, and conditions inside a sanitary bin between collections are unobserved [1], [2]. Instrumenting the bin addresses both problems directly, and the cost of doing so has fallen to a few dollars per node with Wi-Fi microcontrollers such as the ESP8266 [9].

Sanitary waste raises a further concern beyond fill level. Enclosed containers holding organic and sanitary material generate odour and decomposition gases, and the enclosure itself concentrates them. A node that senses air quality inside the bin and ventilates or alerts on a threshold addresses a hygiene problem that scheduling alone cannot.

This paper documents such a node: gas, temperature and humidity sensing feeding an ESP8266 controller which drives an exhaust fan and an alarm and publishes conditions to a mobile application. The design is described in full, and the paper then examines carefully which of the project's stated functions, being segregation, disposal and monitoring, the documented hardware actually supports.

1. Problem Statement

Reported smart-bin systems frequently combine a fill-level or air-quality sensor with a claim of automatic waste segregation, without establishing that the chosen sensors carry information capable of distinguishing the material categories in question. Sensor selectivity is the neglected question: a sensor that responds to a property shared by several waste categories cannot separate them however well the actuation is engineered. A second and equally neglected question is range: a sensor whose detection span begins well above the concentrations of interest cannot report them at all. This paper makes both questions explicit for its own design.

2. Objectives

The specific objectives of the work are as follows:

- To document the node completely, distinguishing the hardware that appears in the block diagram from the functions described only in prose.
- To establish, from sensor physics rather than from testing, what the chosen sensor set can and cannot be used to decide.
- To compare the fitted device's stated detection span against the concentrations at which the gases relevant to sanitary waste actually matter.
- To evaluate the ventilation relations at bin scale so that the fan's role is understood rather than assumed.
- To state explicitly that no measurement was recorded, and to identify the specific quantities a sorting or monitoring claim would require.
- To identify material carried over from unrelated projects and to give a corrected scope statement for the system as built.

3. Scope and Delimitation

The study covers the node as documented, the relations governing gas sensing, selectivity, ventilation and alerting, and the specification of the measurements that were absent. It excludes any claim of gas concentration, alert threshold in absolute units, classification accuracy, fill level, ventilation effect or alert latency, because none was measured. It excludes the servo-based sorting and automatic tipping described in the project text, because no such hardware appears in the documented design. And it excludes the pipeline leak-detection, oil-level monitoring and development-environment tutorial passages found in the source material, which belong to other work.

4. Contributions

1. A complete description of the documented node, being sensing, control, actuation and alerting, distinguished from the functions described only in prose.
2. A capability analysis showing that gas and humidity sensing can separate wet from dry waste but cannot discriminate metal, plastic or glass, independent of implementation quality.
3. A range analysis, new to this revision, comparing the fitted device's stated detection span against published exposure and odour thresholds for the gases sanitary waste actually produces.
4. A bin-scale evaluation of the ventilation relations, new to this revision, which reframes the fan's design question from dilution speed to steady-state balance against generation rate.
5. An explicit statement that no measurement was recorded, with the specific quantities a sorting or monitoring claim would require.
6. Identification of material carried over from unrelated projects, and a corrected scope statement for the system as built.

The remainder of the paper is organised as follows. Section II reviews related work and fixes the reference values. Section III gives the governing relations. Section IV describes the documented node. Section V is the capability audit. Section VI discusses the findings, Section VII states the limitations, and Section VIII gives the measurement and development plan. Sections IX and X give the conclusion and the future scope.

Related Work

Instrumented waste collection has been reported in several forms. Sensor-node approaches using low-power wide-area networking to report bin fill state, with collection routes optimised from the resulting data, are described in [1]; route-planning formulations for selective collection are developed in [2]. Segregation-oriented systems combining sensing with actuated bins are reported in [3] and [4], and broader smart-bin architectures in [5].

On sensing, Wang and colleagues [6] review metal-oxide gas sensors and establish the two properties that govern the present design: a power-law resistance response to target concentration, and pronounced cross-sensitivity, so that a given response can arise from several gases. This is central to Section V-B, because selectivity determines what a sensor can be used to decide. Where material identification is genuinely required, the reported approaches are inductive, capacitive, optical or near-infrared [7], since these respond to material properties rather than to emitted gas. Machine-learning approaches to household waste classification are reported in [8], generally operating on images rather than gas signatures. The ESP8266 platform [9] and the Blynk framework [10] supply the compute and dashboard layers used here.

Table 1. Representative Related Work and its Relation to This Study

Ref.	Year	Focus and scope	Method and validation	Relation to this work
[1]	2018	Low-power bin sensing and routing	Deployed nodes; route optimisation	Fill-level monitoring precedent
[2]	2019	Selective collection path planning	Optimisation study	Motivates need-based collection
[3]	2019	Segregation and monitoring	Prototype with actuated bins	Closest comparable architecture
[4]	2019	Smart dustbin management	Prototype; alerting	Bin-level alerting precedent
[5]	2018	Smart dustbin for community use	Prototype	System context
[6]	2010	Metal-oxide gas sensing	Review of response and selectivity	Basis of Section V-B
[7]	—	Material identification methods	Inductive, optical, NIR sensing	What material sorting requires
[8]	2020	Waste classification by learning	Image-based models	Alternative route to segregation
[11]	—	Occupational exposure limits for hydrogen sulphide	Regulatory and advisory limits	Reference concentrations, Table 2

1. Reference Concentrations for the Gases That Matter

Section V-B turns on whether the fitted device can report the gases sanitary waste actually produces. Answering that requires knowing the concentrations at which those gases matter, which are published. Table 2 collects them.

Table 2. Published Reference Concentrations for Sanitary-Waste Gases

Item	Concentration	Basis
Hydrogen sulphide, odour threshold	About 0.008 ppm	Geometric mean of reported threshold odour concentration [11]
Ammonia, odour threshold	About 0.05 ppm	Reported odour threshold in the sanitation literature [11]
Hydrogen sulphide, 8 h threshold limit value	1 ppm	ACGIH recommendation [11]
Hydrogen sulphide, short-term exposure limit	5 ppm	ACGIH recommendation [11]
Hydrogen sulphide, ceiling value	10 ppm in some jurisdictions	Occupational hygiene practice [11]
Ammonia, odour-irritation threshold range	About 4 to 8 ppm	Sanitation odour literature [11]
MQ-6 stated detection span	200 to 10,000 ppm, for liquefied petroleum gas	Device specification as quoted in the source material

Exposure and odour figures are published values for the gases named. The MQ-6 span is the figure quoted in the project's own source material and is reproduced here for comparison; the device was not independently characterised in this work, and no concentration of any kind was measured on this prototype.

Governing Relations

1. Gas Sensing

A metal-oxide element reports a resistance whose ratio to its clean-air baseline follows approximately

$$\frac{R_s}{R_0} = a\,C^{-b} \tag{1}$$

with a and b specific to the target gas and the individual device, and with R_0 drifting under temperature and humidity [6]. A firmware threshold τ applied to the raw analogue count is therefore a threshold on the resistance ratio, not on concentration, unless Eq. (1) has been inverted using a calibration against a known mixture.

2. Selectivity and Decidability

For a sensor to support a classification decision between categories k, the distributions of its response must be separable across those categories. Where two categories produce overlapping responses,

$$p(R_s \mid k_1) \approx p(R_s \mid k_2) \tag{2}$$

no threshold and no downstream processing can separate them: the information is absent at the sensor, not lost in the algorithm. Equation (2) is the formal basis of the capability finding in Section V-B.

3. Enclosure Ventilation

For a bin of volume V_b served by an extraction fan of flow Q_v, the air-change rate is

$$n = \frac{3600\,Q_v}{V_b} \quad [\mathrm{h}^{-1}] \tag{3}$$

and under perfect mixing a passive contaminant decays as

$$C(t) = C_0\,e^{-nt} \tag{4}$$

Equation (4) describes what happens after a source stops. Where the source continues, as it does in a bin holding decomposing material, the relevant quantity is the steady-state concentration a given extraction rate sustains against a generation rate S,

$$C_{ss} = \frac{S}{Q_v} \tag{7}$$

Equation (7) is the form that actually governs a ventilated bin, and it is developed in Section V-D. Neither Q_v nor V_b is documented for this build, and S was not measured.

4. Alerting and Classification Metrics

The alert path decomposes into detection, uplink, cloud relay and delivery,

$$T_{sys} = t_1 + t_2 + t_3 + t_4 \tag{5}$$

and any classification function is characterised by its accuracy and error rates,

$$A = \frac{\text{correct decisions}}{\text{total trials}} \times 100\,\% \tag{6}$$

with P_{fp} and P_{fn} as defined for the two error directions. None of these was evaluated.

The Documented Node

1. Architecture

Figure 1 reproduces the architecture as documented in the project's block diagram. A gas sensor, a temperature sensor and a humidity sensor feed the ESP8266-based controller. The controller drives a motor-driver stage operating an exhaust fan, and an alarm; it maintains a Wi-Fi session with a cloud service so that bin conditions appear on a mobile application. A transformer, rectifier and regulator chain supplies the logic rails. The two elements shown as absent at the foot of the figure are the ones on which Section V-A turns.

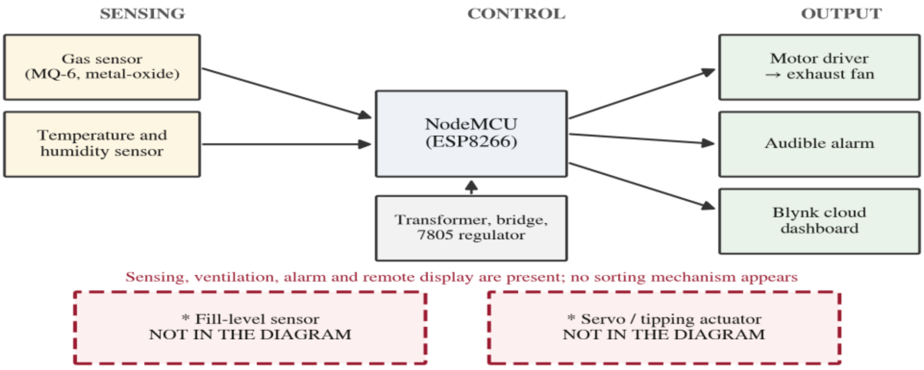

Figure 1: The node as documented in the project's block diagram. Sensing, ventilation, alarm and remote display are present; no sorting mechanism appears.

2. Apparatus

Table 3 lists the node as documented.

Table 3. Node as Documented

Item	Type / rating	Quantity
Controller	NodeMCU (ESP8266)	1
Gas sensor	MQ-6, metal-oxide	1
Temperature-humidity sensor	DHT11 or DHT22 class	1
Driver module	Motor driver	1
Exhaust fan	Rating not stated in the record	1
Alarm	Audible	1
Power supply	Transformer, bridge rectifier, 7805 regulator	1
Dashboard	Blynk (cloud)	1

The fan's volumetric flow and the bin volume are not recorded, which is why Section V-D must use assumed values. No servo motor, bin-selection actuator, tipping mechanism or fill-level sensor appears anywhere in the documented design.

Capability Audit

1. Described Function Against Documented Hardware

The project text describes servo motors directing waste into category bins under microcontroller control, and an automatic tipping mechanism that empties the bin when it reaches capacity. Neither appears in the documented block diagram, the component list or the power-supply design: there are no servo motors, no bin-selection actuator, no tipping mechanism and no fill-level sensor of any kind. Fig. 2 sets the described elements against the documented ones. The single actuated output is a motor-driver stage operating an exhaust fan.

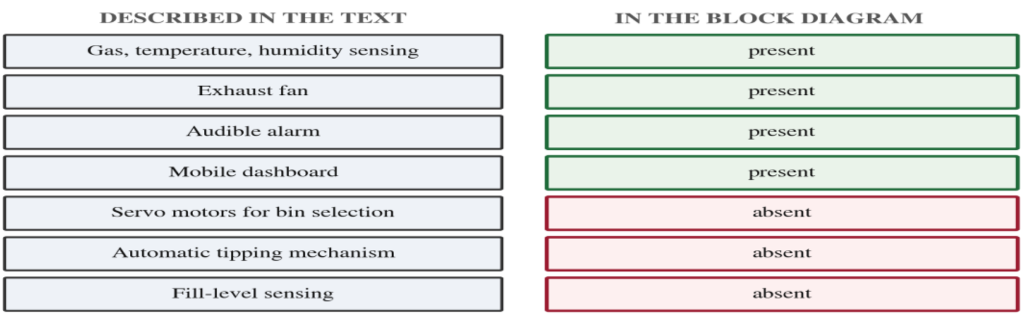

Figure 2: Elements described in the text against those documented in the block diagram.

This matters because the two functions named in the project's title, sorting and disposal, are precisely the two for which no hardware is documented. The node as documented performs air-quality and condition monitoring inside a bin, with ventilation, local alarm and remote display. That is a coherent and useful function, and it is the function this paper credits the work with.

2. Sensor Selectivity and the Sorting Claim
Even if the actuation were fitted, the chosen sensor set bounds what can be decided. Gas and humidity sensing responds to emitted volatiles and moisture content. This does support a wet and dry distinction: decomposing organic matter releases moisture and characteristic gases, while dry recyclables do not.
It does not support the categories the project's own problem statement identifies. Metal, plastic and glass are all dry, chemically stable at ambient temperature and essentially non-emitting; their gas and humidity signatures are mutually indistinguishable, so Eq. (2) applies and no threshold can separate them. Fig. 3 illustrates the point. Separating those materials requires sensing that responds to material properties: inductive sensing for metals, capacitive or optical for plastic and glass, or near-infrared spectroscopy [7], or image-based classification [8]. None is present.

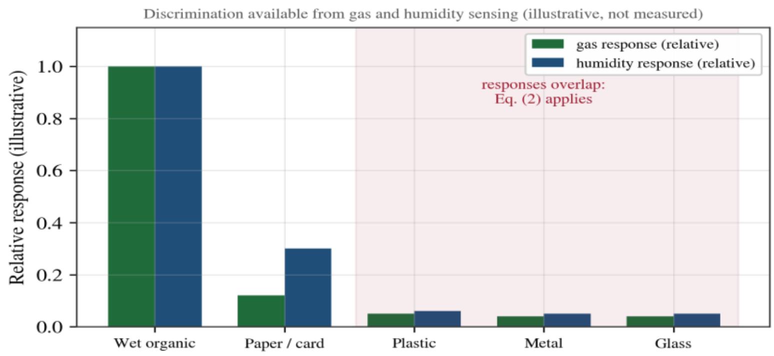

Figure 3: Discrimination available from gas and humidity sensing against the categories the project's problem statement names. Responses are illustrative of the argument, not measurements.

Table 4. Sensing Modality Against the Material Property It Responds To

Modality	Property sensed	Categories it can separate
Metal-oxide gas	Emitted volatiles	Wet organic from dry, at best; not metal, plastic or glass
Humidity	Moisture content	Wet from dry; not among dry materials
Inductive	Electrical conductivity	Metal from non-metal
Capacitive	Permittivity	Some separation among dry dielectrics
Optical or near-infrared	Reflectance and absorption bands	Polymer types and glass, with known difficulty for dark materials
Camera with a trained classifier	Appearance	Broad categories, subject to a validated accuracy [8]

This table states which physical property each modality responds to and therefore which distinctions are available in principle. It is not a performance comparison, and no modality other than the first two is present in this build.

3. The Device Is Also Mismatched in Range
A second point concerns the specific device, and this revision makes it quantitative. The MQ-6 is characterised for liquefied petroleum gas, principally butane and propane. The gases relevant to sanitary waste are different: methane from anaerobic decomposition, and ammonia and hydrogen sulphide from protein breakdown. A metal-oxide element will respond to these through cross-sensitivity, but its response is neither calibrated nor selective for them.
Table II shows that the mismatch is not only one of selectivity but of range. Hydrogen sulphide carries an eight-hour threshold limit value of 1

ppm and a short-term exposure limit of 5 ppm, and is perceptible by odour at around 0.008 ppm; ammonia is perceptible at about 0.05 ppm and becomes irritating in the range of roughly 4 to 8 ppm. The device's stated detection span, as quoted in the project's own material, begins at 200 ppm. The concentrations at which the relevant gases matter therefore lie a factor of 40 to 200 below the bottom of the stated span, and some four orders of magnitude below it at the odour threshold. Fig. 4 places these on a common logarithmic axis.

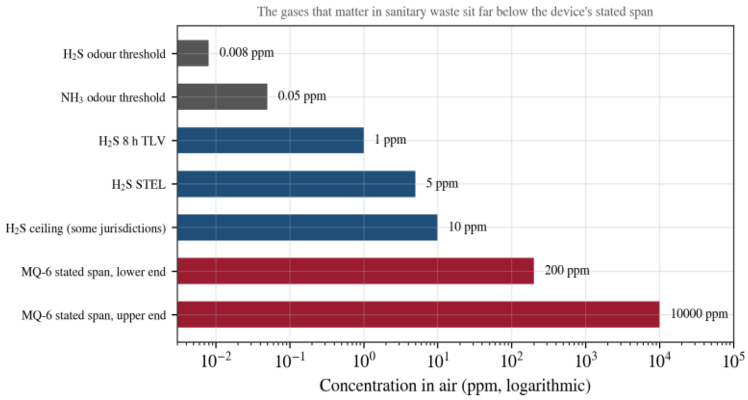

Figure 4: Published exposure and odour thresholds for the gases sanitary waste produces, against the fitted device's stated detection span. The horizontal scale is logarithmic.

The consequence is worth stating carefully. This does not mean the node will read nothing; a metal-oxide element out of its characterised range still produces a varying output, and a firmware threshold on that output may well correlate with bin condition in practice. It means that the output cannot be interpreted as a concentration of anything, that a threshold set on it cannot be referenced to any health or odour criterion, and that a sensor targeted at the gases of interest, or a calibrated cross-sensitivity characterisation, would be needed before any threshold could be defended.

4. What the Ventilation Stage Can Achieve

The fan is the node's only actuated output, and its effect can be examined even though neither its flow nor the bin volume is documented. Table 5 evaluates Eqs. (3) and (4) for two plausible bin volumes and two small-fan flows. Fig. 5 plots the decay.

Table 5. Air-Change Rate and Dilution Time at Bin Scale (Computed from Assumed Values)

Bin volume	Fan flow	Air-change rate n	Time to reach 10 %
20 L	30 L/min	90 per hour	92 s
20 L	120 L/min	360 per hour	23 s
60 L	30 L/min	30 per hour	276 s
60 L	120 L/min	120 per hour	69 s

Computed from Eqs. (3) and (4) for assumed bin volumes and fan flows, with perfect mixing. Neither the fan flow nor the bin volume is documented for this build, so these describe a class of arrangement rather than this device.

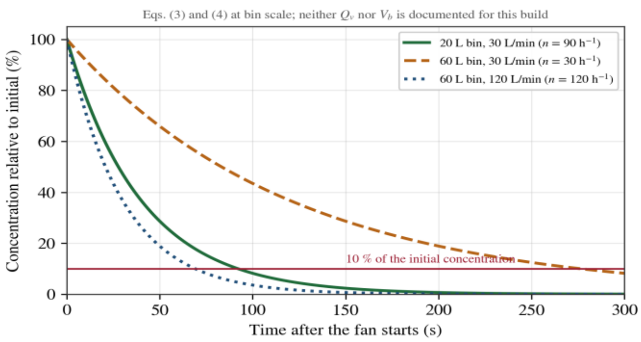

Figure 5: Dilution of a passive contaminant at bin scale under Eqs. (3) and (4), for two bin volumes and two fan flows.

The result reframes the design question usefully. At bin scale even a very small fan produces air-change rates of tens to hundreds per hour, so dilution after a transient is a matter of seconds to a few minutes. Ventilation is therefore not difficult here, which distinguishes this case from room-scale ventilation. What governs the steady state is Eq. (7): the concentration the bin settles at is the generation rate divided by the extraction flow, so the fan must be sized against how fast the contents produce gas, not against how fast a fixed charge disperses. That generation rate was not measured, and it is the quantity a sizing exercise for this stage would need.

5. Why No Performance Figure Is Reported

No measurement of any kind was recorded during the campaign. Specifically:

- No gas concentration, calibrated or raw, so Eq. (1) is un-inverted and the alert threshold corresponds to no stated concentration;
- No classification trial, so accuracy in Eq. (6) and the error rates are unknown; Fig. 6 shows the result that a sorting claim requires and that does not exist;
- No fill-level record, so the disposal trigger is unevaluated;
- No fan flow, bin volume or generation rate, so Eqs. (3), (4) and (7) cannot be evaluated for this build and the ventilation stage's effect is unknown;
- No time stamps on the alert path, so T_{e2e} in Eq. (5) is indeterminate.

Accordingly, this paper reports no accuracy, concentration, latency or efficiency figure, and estimates none.

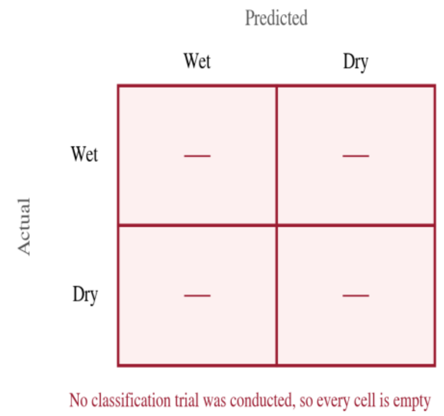

Figure 6: The confusion matrix a segregation claim requires. No classification trial was conducted, so every cell is empty.

6. Material Belonging to Other Projects

Three passages in the source material describe systems unrelated to waste management and are excluded from this paper. The abstract contains a description of pipeline leak detection using acoustic sensors, pressure sensors and thermal-imaging cameras to improve pipeline integrity, and a description of a sensor network for process-plant operation using flow and temperature sensors; neither relates to the bin node. The body contains a passage stating that the devices detect fuel level and that when the oil level exceeds a specified value the user closes the oil valve through a relay; this describes an oil or liquefied-petroleum-gas monitoring installation, and it is consistent with the choice of an LPG-targeted MQ-6 sensor and with the fan-and-alarm architecture of Fig. 1. A fourth block of text reproduces general tutorial material on the Arduino development environment and on consumer, wearable and healthcare applications of the Internet of Things, which is background rather than contribution. Retaining such material would misrepresent the scope of the work, and it has been removed rather than paraphrased.

7. What the Campaign Supports

Table 6 states the position element by element. It is the central table of the paper.

Table 6. Documented, Described, Unavailable and Indeterminate Elements

Element or quantity	Value	Status
Gas, temperature and humidity sensing	present	documented
Exhaust fan and alarm	present	documented
Cloud dashboard	present	documented

Every entry marked indeterminate, absent or not documented is exactly that. An earlier draft of this work carried values against several of these rows, including a two-way servo sorting and a ninety-degree tipping actuation marked demonstrated, a fill-level range and a three-category sort marked implemented, and estimated figures for gas concentration, alert threshold, classification accuracy, alert latency and fan flow. None of those elements exists in the documented hardware and none of those quantities was measured; every one contradicted the body of this paper. They have been removed and the rows restored to their correct status.

Discussion

The node as documented is a coherent piece of engineering for the function it actually performs. The difficulty is entirely one of description: a title and a problem statement promise material segregation, and the hardware performs condition monitoring. These are different systems, and the gap between them is not a matter of implementation quality but of what the chosen sensors can be used to decide.

1. A Corrected Scope Statement

On the evidence available, the work is accurately described as follows: an IoT-instrumented sanitary bin node that monitors gas response, temperature and humidity inside the container, ventilates through an exhaust fan and raises a local alarm on threshold, and publishes conditions to a mobile application for remote awareness. Sorting and automatic disposal are proposed extensions, not realised functions. Stated this way the contribution is modest but defensible, which is preferable to a broader claim the hardware cannot support.

2. Qualitative Position

Table 7 sets out the structural properties that can be asserted, each with the relation or source that supports it.

Table 7. Qualitative Properties and Their Basis

Feature	Property	Basis
Gas sensing	Ratio output; cross-sensitive; uncalibrated	[6], Eq. (1)
Device range	Stated span begins far above the concentrations of interest	Table II
Humidity sensing	Supports a wet and dry distinction	Section V-B
Material sorting	Not decidable from gas or humidity	Eq. (2), Table IV
Exhaust fan	Dilutes quickly at bin scale; steady state set by generation rate	Eqs. (3), (7)
Local alarm	Immediate; independent of network	This work
Cloud dashboard	Remote awareness; fails with coverage	This work

Limitations

The following limitations bound every claim made in this paper.

- No measurement of any kind was recorded. Gas concentration, alert threshold in absolute units, classification accuracy, error rates, fill level, ventilation effect and alert latency are indeterminate for this build, not merely uncertain.
- The gas channel was never calibrated against a known mixture, so Eq. (1) is un-inverted and the firmware threshold corresponds to no stated concentration.
- The absence of servo, tipping and fill-level hardware is established from the documented block diagram and component list. If such hardware exists but was not documented, the finding of Section V-A would need revisiting; the documentation available does not show it.
- The MQ-6 detection span in Table II is the figure quoted in the project's own source material. The device was not independently characterised, and its actual cross-sensitivity to hydrogen sulphide, ammonia and methane was not measured.
- The selectivity argument of Section V-B is a statement about what information the sensing modality carries. It is not a measurement, and Fig. 3 is illustrative of the argument rather than experimental data.
- The ventilation figures of Table V use assumed bin volumes and fan flows with perfect mixing, and the generation rate needed for Eq. (7) was not measured. They describe a class of arrangement, not this device.
- The exposure and odour figures in Table II are published values for the gases named, not measurements of any bin.
- The wet and dry distinction is stated as available in principle from the sensing modality. It was not validated, and no confusion matrix exists for it.

Proposed Measurement and Development Plan

Fig. 7 shows the path from the documented node to an evaluated one, and then to the segregation function if it is to be pursued. The ordering is the substance of the recommendation.

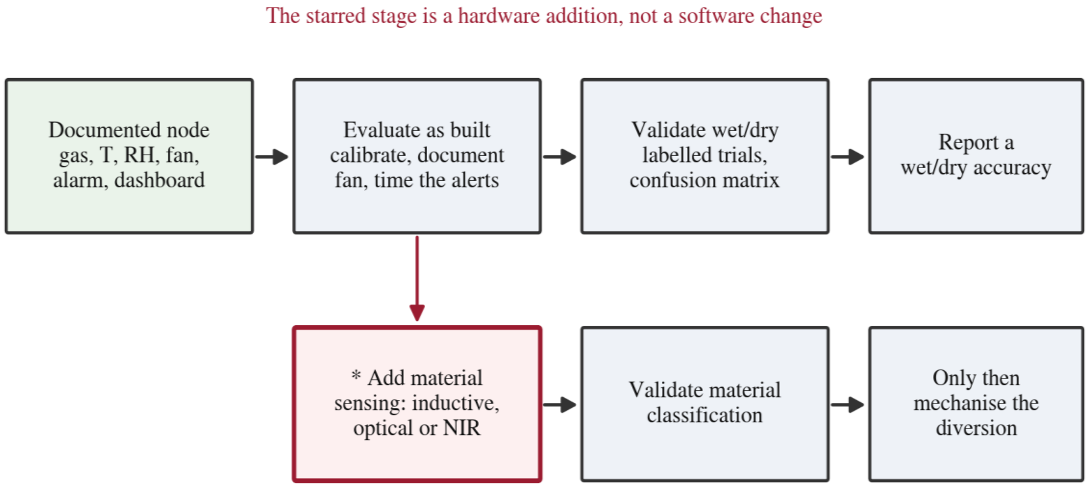

Figure 7: Development path. The starred stage is a hardware addition, not a software change.

1. Evaluating the Node as Built

Three measurements convert the existing node into an evaluated instrument: calibration of the gas channel against a known mixture so that Eq. (1) can be inverted; documentation of fan flow and bin volume so that Eq. (3) yields an air-change rate and the ventilation effect becomes computable; and time stamps on the alert path so that Eq. (5) yields a latency. None requires new hardware beyond a reference gas source. A fourth, following from Section V-C, is to characterise the fitted device's response to hydrogen sulphide and ammonia at the concentrations of Table II, or to replace it with an element targeted at those gases.

2. If Segregation Is to Be Pursued

Adding servo motors to the present sensor set would produce an actuator with nothing reliable to act on. The order of work should be reversed: first add sensing that responds to material, being inductive for metal, optical or near-infrared for polymer and glass, or a camera with a trained classifier; then establish accuracy over labelled trials; and only then mechanise the diversion. A wet and dry split is achievable with the present sensors and is a reasonable first target, but it should be validated with a confusion matrix before it is claimed.

3. Measurement Plan

Table 8 sets out the measurements required, and Table 9 gives the context values that are device specifications or literature rather than results.

Table 8. Measurement Plan Required Before Any Performance Claim

Measurement	Method	What it yields
Calibrate the gas channel	Exposure to known concentrations of the gases actually present	Constants of Eq. (1); a threshold in ppm rather than raw counts
Characterise cross-sensitivity	Response to hydrogen sulphide, ammonia and methane at the levels of Table 2	Whether the fitted device can report the gases of interest at all
Document the ventilation stage	Fan flow and bin volume; controlled release and decay measurement	Air-change rate through Eq. (3); validates Eq. (4)
Measure the generation rate	Sealed-bin accumulation test with the fan off	S, and hence the steady state through Eq. (7)
Add fill-level sensing	Ultrasonic ranger in the lid	The fill state on which need-based collection depends
Time the alert path	Time stamps at the four stages of Eq. (5)	T_{e2e} as a result rather than an assumption
Validate wet and dry classification	Labelled trials with the confusion matrix published	Accuracy through Eq. (6) and the two error rates
Add material sensing before actuation	Inductive, optical, near-infrared or image-based	The precondition for any segregation claim beyond wet and dry

Table 9. Illustrative Figures (Specifications and Literature, Not Results)

Item	Illustrative value	Status
MQ-6 stated detection span	200 to 10,000 ppm	device specification as quoted in the source material
MQ-6 target gas	LPG, principally butane and propane	device specification
DHT-series operating range	About −10 to 50 degrees Celsius	device specification
Hydrogen sulphide 8 h limit	1 ppm	published exposure limit [11]
Bin-scale air-change rate	Tens to hundreds per hour	computed from assumptions, Eq. (3)

Device specifications are quoted from vendor data and from the project's own material for orientation. Nothing in this table was measured on the prototype.

Conclusion

An IoT node for sanitary waste bins was documented, comprising gas, temperature and humidity sensing, an ESP8266 controller, an exhaust fan, an audible alarm and a mobile dashboard. The paper documented that architecture and then audited the project's stated capabilities against it.

The block diagram contains no servo motors, no bin-selection actuator, no tipping mechanism and no fill-level sensor, so the automatic sorting and disposal named in the project title are described in prose but not evidenced in hardware. Independently of that, the chosen sensor set bounds what could be decided even if actuation were added: gas and humidity sensing supports a wet and dry distinction, but metal, plastic and glass are dry, stable and non-emitting, so their responses overlap and no threshold can separate them. The information is absent at the sensor rather than lost in processing.

This revision established a second, quantitative mismatch. The gases that matter in sanitary waste are hydrogen sulphide and ammonia, which carry exposure limits of a few parts per million and odour thresholds three orders of magnitude below that, while the fitted device is characterised for liquefied petroleum gas over a stated span beginning at 200 ppm. The concentrations of interest therefore sit a factor of 40 to 200 below the bottom of that span. The device may still produce a useful correlate of bin condition, but its output cannot be interpreted as a concentration and a threshold set on it cannot be referenced to any health or odour criterion.

The ventilation stage was evaluated at bin scale and found to dilute a transient in seconds to a few minutes even with a very small fan, which reframes its design question: the binding constraint is the steady-state balance against the rate at which the contents generate gas, and that rate was not measured. No measurement of any kind was recorded, so concentration, classification accuracy, fill level, ventilation effect and alert latency are all indeterminate and none is reported. Passages describing pipeline leak detection, oil-level monitoring with a valve relay, and general development-environment tutorials were identified as belonging to other work and excluded. A corrected scope statement was given, being an instrumented bin node providing condition monitoring, ventilation and remote awareness, together with a development path in which material-responsive sensing precedes actuation and validation precedes any segregation claim.

Future Work

Several extensions follow directly from the limitations above.

- Calibrate the gas channel-Expose the sensor to known concentrations of the gases actually present in sanitary waste, so that a threshold can be stated in ppm rather than raw counts.
- Match the sensor to the application-Characterise the fitted device's response to hydrogen sulphide and ammonia at the concentrations of Table 2, or fit an element targeted at those gases and at that range.
- Document the ventilation stage-Record fan flow and bin volume, measure the decay of Eq. (4) after a controlled release, and measure the generation rate needed by Eq. (7).
- Add fill-level sensing-An ultrasonic ranger gives the fill state on which need-based collection depends, and which the current node lacks entirely.
- Time the alert path-Instrument the four stages so that latency becomes a result.
- Add material sensing before actuation-Inductive, optical or image-based sensing is the precondition for any segregation claim beyond wet and dry.
- Validate wet and dry classification-Run labelled trials and publish the confusion matrix of Fig. 6 with real numbers in it.

- Correct the scope-Align the title and abstract with the realised function, and remove the pipeline, oil-monitoring and tutorial material.

Acknowledgment
The authors thank the Department of Electrical and Electronics Engineering, Stella Mary's College of Engineering, for laboratory facilities and guidance during the project.

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