

## Response to Enviroserv emission data, modelling and ambient monitoring data

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24 May 2017

### 1 Introduction

This opinion reviews the following aspects of the air monitoring data submitted by Enviroserv to Upper Highway Air NPC during the development of a health risk assessment for the Shongweni site near Durban in KwaZulu Natal. The air concentration data is used as a comparison against levels of pollution that have resulted in health effects. If the measurements or extrapolations provided by Enviroserv and its advisers are wrong, then the health risk assessment could be misleading. I have considered the following logical flow of data:

1. Enviroserv has conducted various qualitative and quantitative surveys of air pollution leaving its site. These include:
  - a. Emission measurements from the exposed surfaces of the landfill and surrounds
  - b. Emission measurements from extraction vent piping (Whirlybirds)
  - c. Emission measurements from dams, tanks and holding areas
  - d. Ambient air measurements above the surface of the landfill
  - e. Ambient air measurements at the site fenceline
  - f. Ambient air and weather measurements undertaken some distance from the site
2. Airshed has performed a mathematical exercise to project how the air pollution emissions from the site translate into air pollution that residents living near the site are exposed to. This exercise involves the consolidation of emission data, site characteristics, terrain information and local weather data as inputs to a series of mathematical routines that describe how chemical plumes disperse from the site. The emission data is critical as an input and the model output, in the form of calculated exposure concentrations, is in turn critical to the decisions made on the health risk posed by the site to the surrounding residents.
3. There is limited ambient data measured by Enviroserv. This data, while valuable in its own right, is important to validate whether the output of the dispersion simulation is reliable. If the data disagree it could be because the measured emission data is wrong or because the simulation is defective. Either way, the conclusions of any health-based decisions could be incorrect in this scenario.

## 2 Documents reviewed

The following documents and data sets were made available for review.

1. Re-energise Africa, Letter to Envitech of 2 February 2017
2. Envitech Report: Technical Assessment- Shongweni Landfill Site, Final Report 14 March 2017.  
Reference: 548-2016-R003
3. Infotox Report and appendices, including:
  - a. Community Health Risk Assessment for the EnviroServ Shongweni Waste Disposal Facility Progress Report No 016-2016 Rev 1.0, 12 December 2016
  - b. Source Sampling Report for the Shongweni Health Risk Assessment, Report no 020 2017 Rev 2.0
  - c. Community Health Risk Assessment for EnviroServ, Shongweni, Report 016-2017 Rev 3.0
  - d. Technical Report No 010-2017 Rev 1.0 12 February 2017, Cross Interference with Electrochemical Hydrogen Sulphide Sensor Readings
4. Airshed modelling report: Atmospheric Dispersion Simulations of Gaseous Emissions from the Shongweni Landfill Site West of Durban, April 2017, Reference: 16EWM01
5. Powerpoint presentation: *On-line emission monitoring at Shongweni landfill* March 2017, referred to as the Schoonraad presentation
6. Technical Note TN-114 11/16/VK RAE Systems by Honeywell 877-723-2878 raesystems.com SENSOR SPECIFICATIONS AND CROSS-SENSITIVITIES (attached)
7. Technical Note TN-148 12/15/VK RAE Systems by Honeywell 877-723-2878 raesystems.com DEFINING THE INTERVAL BETWEEN CALIBRATION CHECKS (attached)

## 3 Emission inventory

Envitech, in their report of 14 March 2017, conducted a qualitative assessment followed by a quantitative assessment. They concluded that the concentrations measured corresponded with their impressions of the sources of the odour sources. They included diagram 6.10 on page 102 of their report, identifying the stone drain, the southern slope of Valley 2 and the leachate treatment plant as the major sources of the odour. Their measurements were conducted using a GA-5000 instrument, a unit certified by the well-recognised M-Certs acceptance scheme for use in this application. They indicated that the unit was calibrated but provided no evidence of this in their report. Most of the measurements conducted for the Valley 2 Whirlybirds during the first quarter of 2017 indicate emission concentrations of hydrogen sulphide in excess of 1500 mg/m<sup>3</sup>.

Re-energise Africa measured landfill gas concentrations from vents P2 and P3 (below the carbon filter). They note that the air in the vent is potentially diluted (refer to bullet 2 of their report), but

nevertheless still comprises relatively high hydrogen sulphide concentrations of 29600 and 16500 mg/m<sup>3</sup>. The Envitech report (pages 92 to 95) shows that the carbon filters have an uneven scrubbing effect, ranging from an additive impact to about a 50% reduction in certain instances for Valley 1. For Valley 2 filters, almost all values exceed the instrument upper detection limit. Assuming scrubbers were working in the 50% efficiency range, this would still put the landfill gas emission concentrations in the scrubbers in the range of 8250 to 14800 mg/m<sup>3</sup>.

Infotox measured gas concentrations from various points across the landfill during late 2016 and early 2017. Handheld instruments and whole-gas samples (collected in canisters) were used in this exercise.

I have the following concerns about this data set, foremost of which is the exclusion of the "over-range" or ">1000" results for the purposes of presenting an emission inventory for the site. In a technical report from Infotox to Enviroserv (12 February 2017, 010-2017 Rev 1.0), after initially releasing its report, Infotox then suggests that all over-range results obtained in its own survey are excluded. The reasons given include:

- The instruments used by Infotox are subject to interference from alcohols found in the leachate.
- Despite these compounds not being identified in Re-energise Africa's and Infotox's own extensive emission analysis, an analysis of the leachate showed high levels of alcohols and, given the temperature of the landfill, one would, according to Infotox, logically expect these compounds to be present in the emission gases.
- According to Infotox's assessment, no-one working on the landfill had experienced any ill effects from exposure to the landfill gases and the logical conclusion of the magnitude of the over-range readings obtained was that people on the site should be reacting negatively.

This is a remarkable piece of correspondence because:

- It is not clarified in any of the other technical reports made available for review.
- The limitations of electrochemical cells have been well understood for some time in my opinion. In TN-114 11/16/VK, a technical note issued by the manufacturer of the Rae instrument used by Infotox, the manufacturers contradict the older paper presented by Infotox. Page 24 of the Note issues the following statement in respect of its hydrogen sulphide sensors:

**Note:** High levels of polar organic compounds including alcohols, ketones, and amines give a negative response.

1 - CAUTION! Negative cross-sensitivities may cause the sensor to produce lower readings than the true concentration of gas in ambient air.”

- The approach contradicts the findings of both Envitech and Re-energise Africa and Infotox’s own laboratory data. At the Eastern Stone Drain, Infotox’s laboratory reports an H<sub>2</sub>S concentration of 6969 mg/m<sup>3</sup>. This latter value is similar to the result obtained by Re-energise Africa.
- Envitech also appears to contradict the approach in its Technical Assessment of March 2017. It reports on the two samples of landfill gas collected by Re-energise Africa as follows:  
“No significant methanol or ethanol was detected in the gas samples. This suggests that interference with measurements taken with portable landfill gas analysis equipment is unlikely.” (Page 9)
- I am not clear on what the correct answer is because after making this statement and instituting this decision, no tests were conducted on the instrument to determine how its data should be interpreted in the context of the landfill gas. The instrument response could have been tested using synthetic gas samples, diluted samples or by an alternative method but this was either not done or not reported. This is a major gap in the scientific approach and reduces the work to a matter of opinion over analysis.
- An additional complication introduced by this correspondence is that the reported range of the Drager instrument is 0 to 1000 ppm. This implies that the upper detection limit is 1500 mg/m<sup>3</sup> H<sub>2</sub>S when converted to a mass/volume concentration basis. Infotox has reported all concentrations on a mass/volume basis in its Annex 1. However, it reports “out of range” values as >1000 mg/m<sup>3</sup> (667 ppm). Is it possible that the units of measure in this table should correctly be parts per million, in which case all direct readings are being under-reported by one third?

The nett impact of the elimination of these sets of emission data would be to significantly reduce the theoretical air pollution load associated with the landfill. This reduces the emissions rate anticipated by the mathematical simulation and will reduce the ambient concentrations projected by the model used in the health risk assessment.

The approach explains the apparent deviation between the Emission Inventory produced by Infotox (in its Annex 1) and the Inventory subsequently used by Airshed in its study report. In particular, the latter appears substantially lower and appears to exclude sections of the Valley 2 emissions.

To illustrate the implications of the emission point elimination, I will use the example of the Eastern Stone Drain presented on pages 14 and 15 of Annex 1. This is one of the main odour sources identified

by Envitech. Infotox presents 21 values measured directly and two laboratory results from samples collected in canisters. Six of the handheld instrument results (about one quarter of the total) are “out of range”. The reported hydrogen sulphide concentration values vary between 1 and 6969 mg/m<sup>3</sup>. The average emission rate calculated by Infotox is 0,75 mg/m<sup>2</sup>-min (Stone Drain 1 results on page 9).

- If one relies on the direct-reading results only, the emission rate reported by Infotox would be 0,08 mg/m<sup>2</sup>-min. However, if we included the six over-range results at the upper limit of detection (1500 mg/m<sup>3</sup>), the emission rate would be 14 times higher at 1,2 mg/m<sup>2</sup>-min.
- If one includes the two relatively higher concentration canister results, the Infotox-calculated emission rate is 1,1 mg/m<sup>2</sup>-min. However, if we included the six over-range results, the emission rate would be 70% higher at 1,9 mg/m<sup>2</sup>-min.
- And if one assumes that the handheld instruments can't be trusted and we rely on the laboratory tests only, then the average, laboratory-derived emission is eight times higher again.
- None of these rates appears to correlate with the published emission rate. This is presumably a matter of source classification but it makes the subsequent correlation of results difficult for the reader.

I include these examples to illustrate the uncertainty introduced by the approach and to illustrate that it potentially has serious ramifications for the interpretation of the air dispersion modelling report results. If, as the data seem to suggest, the emission inventory is under-reported, the calculated exposure values will be under-reported and the health risk assessment will be based on values that are lower than potentially experienced.

There are other issues with the data contained in Annex 1:

- There is no evidence of any gas concentration calibration for any of the equipment used in measuring the emission data. There is one flow calibration conducted by a company not accredited for this service, conducted during the course of the survey.
- The handheld instrument which formed the basis of the bulk of the emission data was not managed in accordance with the manufacturer's recommendations as contained in Technical Note TN-148 12/15/VK RAE Systems: DEFINING THE INTERVAL BETWEEN CALIBRATION CHECKS. In addition, the same document cautions against exposure to high concentrations of gases, such as those evidenced on the landfill. Paragraph 2 states: “The reason [Rae Systems] stress[es] the need to verify accuracy on a regular basis is to guard against any loss of sensitivity due to sensor poisons or suppressors possibly present in the atmosphere being monitored”. The absence of regular calibration suggests a strong possibility that the response

reported by the instrument decreased with time as the project progressed, leading to a reduced reported emissions inventory.

- One such example of this phenomenon appears to be illustrated in Annex 1 on Pages 5, 6 and 8: the readings of various points appear to be repeated, often to four decimal places, suggesting that the instrument was either malfunctioning or the sensor had been poisoned and needed recalibration. The bulk of the results on page 12 (from Wb17 to Wb23) are also remarkably similar.
- The level of correspondence between the landfill gas portable analyser and the canister laboratory samples is mixed for hydrogen sulphide. One would have expected similar results for the same point.
  - a. For instance, on page 1, point 19 has an appreciable response for both tests: the laboratory reports a concentration of 1204 mg/m<sup>3</sup> vs the on-site measurement of 878 mg/m<sup>3</sup>. (Note that if the units of the handheld instrument should actually be in ppm, as suspected, then the on-site result would have been 1317 mg/m<sup>3</sup>, i.e. within 10% of the laboratory result).
  - b. Possibly the most confusing of the results set is for the Valley 1 Whirlybirds, Whirlybird 2, which appears to provide a comparison between the handheld instrument and two canister results. The instrument reports “over 1000 mg/m<sup>3</sup>”, one canister reports <1 mg/m<sup>3</sup> and the other reports 3174 mg/m<sup>3</sup>. The variance suggests again that the omission of handheld values of more than 1000 mg/m<sup>3</sup> was not corroborated by Infotox’s own data but also suggests unreliability of the monitoring data itself.
- None of the laboratories used, despite having extensive scopes of accreditation, have ISO 17025 accreditation for the analyses conducted by them for this project. It is also not clear why different laboratories were selected and what differences there might be between them.

#### **4 Dispersion model**

The Infotox emission data was passed to Airshed to use in the mathematical air pollution dispersion simulation. I have attempted to reconcile the remaining average emission data presented with that used by Airshed.

Airshed presents the emission data that presumably formed the basis for its modelling on Page 22 of its report. It is difficult to determine which sources are grouped to present the average emission data used.

On Page 6 of Infotox Annex 1, however, there is a single direct-reading result for *Valley 2 stormwater dam* (under the Headings Valley 2, Dam and Tank) of 61,8803 mg/m<sup>3</sup>. This is then represented as a Canister Sample emission rate (presumably a transposition error) of 0,138393732 mg/m<sup>2</sup>-min. On unit restatement, this is the same figure used by Airshed for Valley Dam Fluxes of 2.61E-6 g/m<sup>2</sup>-s. Without fully understanding the groupings, it appears that Airshed has relied directly on the figures presented by Infotox for its calculations.

The Stone Drain, Treatment Plant and Whirlybird readings have been modified by Airshed for pressure and wind speed. It is not clear why other sources were excluded from this treatment but it does raise a number of concerns:

- The source of the wind data would be critical and it would be important to ensure that the wind data was reliable and representative. The unit used for wind measurement is a Davis Weather Station (according to Page 95 of the Airshed Report). This would be considered an indicative weather station only when considered for air pollution studies. The unit was calibrated by the supplier, who relied on a calibration standard issued in 2009. This would not normally be considered acceptable.
- The measurement data should be referenced to meteorological conditions at the time of testing. This was not done and the time of measurement was not recorded in Annex 1, making it difficult to scientifically assess the results in relation to any weather trends that the sampling team might have identified.
- Figure 2-4 on Page 20 of the Airshed report demonstrates the difficulty of the approach. The measurement data points offer a limited, narrow opportunity to validate the calculated emission model. Given the uncertainties around the emission data itself, this comparison is of limited value and may even be misleading.
- Airshed relies on pH data supplied by Enviroserv. This data is limited in time and there is no information presented on its uncertainty. The variation in pH presented in Figure 2-4 is less than 1 pH unit. This may well be within the method uncertainty and seems a sparse data set on which to base the model. It would have been helpful if more data were provided in this area.

It would be preferable if these uncertainties in input data were transparent and thoroughly understood.

In terms of the output, on Page 82 of its report, Airshed indicates that the model uncertainty should be within the "often quoted factor of two uncertainty", referencing the United States Environmental

Protection Agency (US EPA 2005). This suggests that the concentrations projected by the model should be viewed in the context of an uncertainty range of -50% to +100%.

## **5 Measurement of exposure concentrations to determine emission inventory and model reliability**

Enviroserv has conducted fenceline monitoring using passive, sorbent samplers and more recently installed continuous monitoring stations both on the fenceline and then in kwaNdegezi and in the Plantations residential estate. Less than two months' continuous monitoring data has been made available for review.

In an earlier report, I commented more fully on the following:

- The analysers used by Enviroserv do not appear to have any recognised quality endorsement and are not referenced to any standard method as is normally the case for compliance monitoring in South Africa and a foundation concept for any monitoring that applies to meet the quality control criteria assessed in ISO 17025.
- No calibration data was made available. There is no evidence that on-site calibrations have been done. A commissioning certificate supplied in the Airshed report appears only to be an electrical acceptance check conducted by the supplier at the time of manufacture. It does not indicate that any acceptance or calibration was done on site after installation.

I have reviewed the data submitted for Plantations and have the following comments:

- The data capture for the period 16 March 2017 to 8 May 2017 is 87%. There are periods when individual measurements are missing from the series and others when a few hours are unaccounted for. Only one instance appears to be an instrument restart (characterised by peak gas concentrations on the restart). The missing data is not accounted for.
- The sulphur dioxide data appears to be a function of the internal temperature of the instrument. For this and reasons previously explained, I have no faith in the reliability of this data and have discounted it for further review. Refer to the graph below (Figures 1 and 2) to show the trend in sulphur dioxide with temperature. (At 23.7°C the instrument appears to report a range of sulphur dioxide values). The data shows a remarkably good correspondence with temperature and it would appear that this is nothing more than a direct temperature indication, not a measure of sulphur dioxide as purported.
- The wind data presented for the Plantations station shows little resemblance in pattern to the wind data presented in the Airshed report in Figure 3-4, page 30. Airshed shows a predominant north easterly wind with almost no winds from the westerly to northerly



quadrant. The Plantations data by contrast shows a limited north easterly component with about a third of the winds from the north westerly quadrant. The wind data for Plantations shows a less distinct pattern than is expected for the region, which suggests that it is less reliable than the original data presented by Airshed.

- Notwithstanding, the same concerns about the instrument and its manner of operation, the H<sub>2</sub>S concentrations distribution appears to respond in a more predictable fashion. There is no apparent trend with instrument temperature visible. However, the ambient hydrogen sulphide concentration reported by the instrument for the same period is 52 ppm. The Airshed model suggests that the 100 percentile for the R4 and R6 receptor points in Plantations is only 18 and 22 ppm by contrast, substantially below the average response. This discrepancy is not explained by Airshed or Infotox and requires more detailed analysis. If it is found to be correct, it supports the hypothesis that the emission inventory has been understated and that the Health Risk Assessment base concentrations should be raised and that the assessment itself is therefore based on levels that are lower than actual and should be re-rated.

## **6 Other issues**

The following comments are made with respect to miscellaneous aspects of the various reports submitted for review. They do not necessarily have a place in the logical development of my assessment of the basis for the Health Risk Assessment.

1. The Envitech report presents the GasSim model that shows that landfill gas generation rates will increase over the next eight years to 2024. Presumably the increase in gas emissions will apply to the total emission load. The health risk assessment makes no allowance for this variation over time.
2. The information presented by Enviroserv in the March 2017 Presentation (Online Emissions Monitoring at Shongweni Landfill) shows that for extended periods the fence line hydrogen sulphide average monthly concentrations were between 80 and 160 ppb (back to 140 ppb in January of 2017 when much of the emissions survey was completed). These concentrations would be considered very high in an urban context. It should be borne in mind that the wind conditions will mean that the samples are likely to be influenced for only approximately 30% of the month (presuming that they are in the direction of the dominant wind direction from the main source). This means that the average concentration of hydrogen sulphide immediately downwind of the site would be approximately 300 to 500 ppb hydrogen sulphide.

By comparison, my own experience with hydrogen sulphide monitoring is in Richards Bay, where our company operated a continuous air monitoring station, we invariably correlated complaints with situations when the concentrations were in the region of 50 ppb or less and there were few incidents when the hydrogen sulphide concentrations exceeded this. Based on my experience, the suggestion made Enviroserv's own data, is that there would be serious and justifiable complaints for communities whenever the wind blows over the landfill towards them.

3. Similarly, even if I accept that the sulphur dioxide levels reported for the Plantations site are in the range reported by Enviroserv, again in my experience, these would be typical of 1990's levels of peak air pollution as experienced in industrial areas in Durban South. In that condition, where industry could release over 125 tpd of sulphur dioxide, ground level concentrations only rarely exceeded 600 ppb in the short-term. The data would appear to indicate that Hillcrest lies in a heavily industrialised zone, a scenario I find unrealistic.
4. Data security. The transfer of data from field notes to the formal spreadsheets was checked. The quality of the scans is poor and it was not always possible to read the field analyst's writing. The following non-zero entry on the first page of the record sheets could be checked.

| Date   | Location | Field record | Field record (recalculated in mg/m <sup>3</sup> ) | Annex 1 published value | % Difference (Annex 1 / Field x 100) |
|--------|----------|--------------|---|-------------------------|--------------------------------------|
| 21-Nov | #27      | 33           | 50  | 46                      | -7%                                  |

5. Most other legible values were zero and were recorded correctly. It is recommended that Infotox makes legible copies of the field record sheets available and that the data transfer is rechecked.
6. It was noted that the tank emission results for Phase 1 were generally recorded as 99.9 ppm H<sub>2</sub>S. It would appear therefore the difference between results reported as "out of range" and ">1000" is that values "out of range" are in fact only greater than 100 ppm, one tenth of the reported upper detection limit. The reasons for this potential discrepancy are not clear.
7. The sample log sheets need clarification. For instance, I refer to the unnumbered page (which in the electronic version reflects as page 44 of 131). On this record sheet there are no sampling times evident yet a series of apparently similar measurements. I anticipate that the purpose of these tests was to determine the impact of pressure and time on the emission rates. However, without having any of the related data, it would be difficult to make any reasonable interpretation.
8. The procedure for canister sampling of the vents appears to be covered in the text presented by ALS laboratory on Page 33 of Annex 4. Not all the text is legible but it would appear that

the canister vacuum if first verified by means of a pressure gauge, thereafter a sample introduction tube of undocumented dimension is fixed to the front of the canister. While the canister walls are coated with an inert material, it is not clear whether the tubing has the same treatment.

9. As the dimensions of the inlet tubing are not known and the mechanism by which this tubing is purged is not clarified, the risk that the sample is diluted exists. This may be dealt with by means of analytical adjustment of via an undocumented procedure. This should be clarified.
10. The methods used to measure the emissions are not included on the Department of Environment's schedule of methods approved for emission testing (Annexure A: Methods for sampling and analysis, *List of Activities which Result in Atmospheric Emissions Which Have or May Have a Significant Detrimental Effect on the Environment...*, issued in terms of the National Environmental Management Air Quality Act). These methods are required for compliance testing and while they do not cover all instances for the Enviroserv situation, they would have provided a more reliable assessment of the hydrogen sulphide emissions in my opinion.

Figure 1: Correlation between internal temperature and reported sulphur dioxide concentration for Enviroserv Plantations analyser

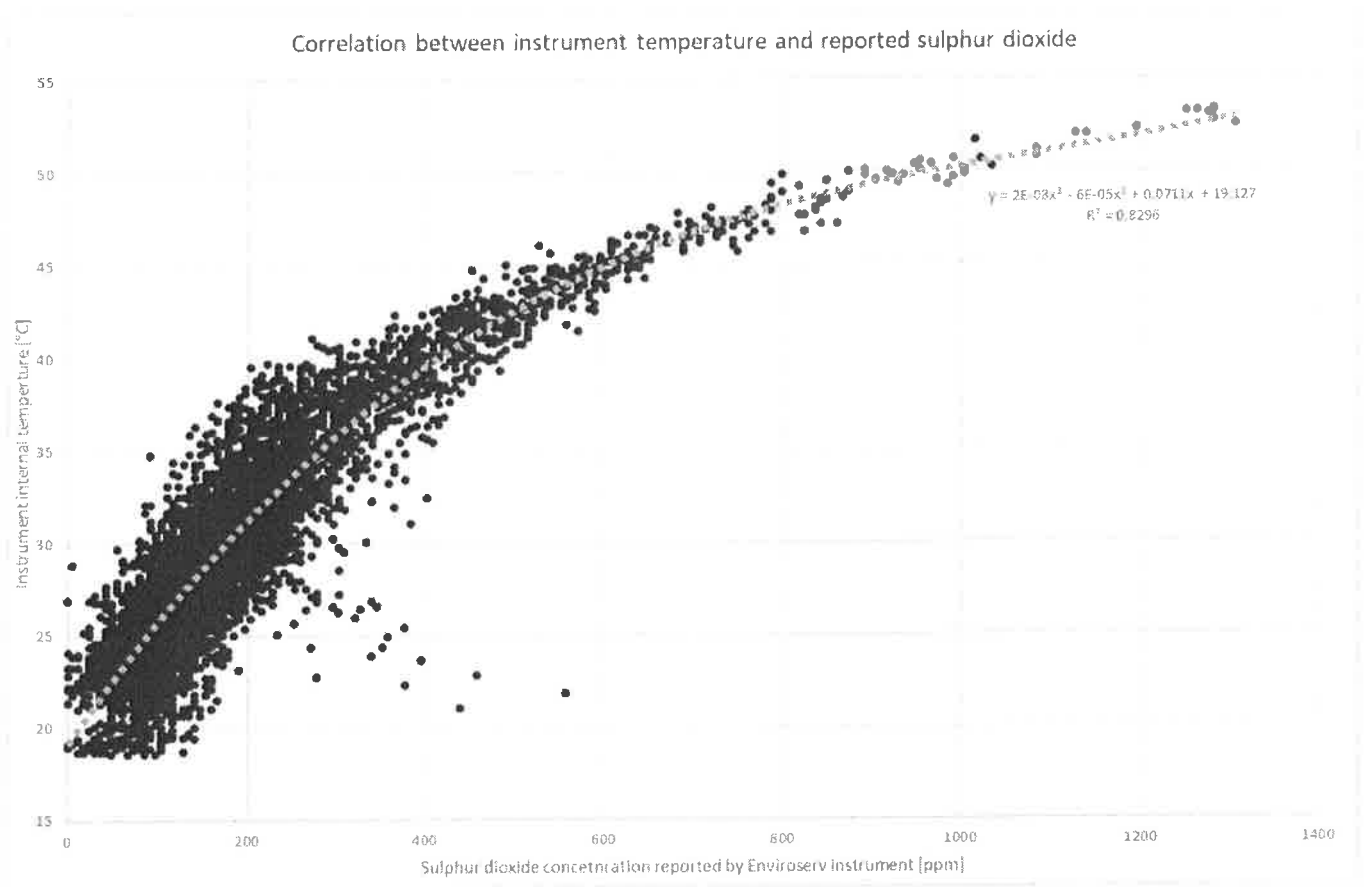


Figure 2: Graph showing correlation between sulphur dioxide (green line) and temperature (blue line) reported by Enviroserv at Plantations

