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# Air monitoring survey of hydrocarbon compounds (BTEX) in the Taranaki Region 2019

## Introduction

In January 2019 the Taranaki Regional Council (TRC) implemented a coordinated region-wide monitoring programme at 20 monitoring sites around the region to measure the concentrations of the volatile organic compounds (VOC) benzene, toluene, ethylbenzene and xylenes (BTEX) using a recognised and long-established passive sampling method. The measurements were taken not only at individual compliance monitoring sites near industries that emit BTEX, but simultaneously at urban sites (within the Council's regional state of the environment programme) to determine exposure levels for the general population. The programme involved deploying all measuring devices on the same day, with retrieval three weeks later. This approach will assist the Council to further evaluate the effects of local and regional emission sources and ambient air quality in the region.

Monitoring for BTEX has been undertaken by TRC as part of the Council's air quality SEM programme and as a component of compliance monitoring programmes for 15 years. The location of the BTEX passive samplers are presented in Figure 1.

The findings of this study are presented in this report.

## Benzene

Benzene occurs naturally in fossil fuels and is produced in the course of natural processes and human activities that involve the combustion of organic matter such as wood, coal and petroleum products. Natural sources of benzene emissions to the atmosphere are estimated in order of 3-5% while more than 90% are estimated to come from anthropogenic sources (gasoline vapours, vehicle exhaust, paint, and chemical production). The route of highest human exposure is through cigarette smoking.

## Toluene

Toluene occurs naturally as a component of crude oil and is a major aromatic constituent of petrol which contains about 5-7% toluene by weight. It is released in the process of making gasoline and other fuels from crude oil, in making coke from coal, and as by-product in the manufacture of styrene. It is used as an intermediate in the manufacture of many end products. Toluene is also used in a mixture added to gasoline to improve octane ratings. Toluene is released into the atmosphere principally from the volatilization of petroleum fuels, from motor vehicle exhaust and from toluene-based solvents and thinners with the largest sources of release the production, transport, and use of gasoline.

## Ethylbenzene

Ethylbenzene is naturally present in crude petroleum. It is also a by-product of biomass combustion. Ethylbenzene is almost exclusively (>99%) used as an intermediate for the manufacture of styrene monomer. Ethylbenzene will enter the atmosphere primarily from fugitive emissions during the use of fuel and solvents (which account for the bulk of emissions) and exhaust connected with its use in gasoline.

## Xylenes

Xylenes exist in ambient air as a mixture of ortho (o-), meta (m-) and para (p-) isomers (the term "xylenes" refers to all three isomers). Xylenes are primarily synthetic chemicals produced from petroleum but also occur naturally in petroleum and coal tar.

In this study concentrations of o-, p-, and m-xylene were summed and reported as xylene total. Xylenes are released to the atmosphere primarily as fugitive emissions from industrial sources (e.g., petrochemical and chemical plants), in automobile exhaust, and through volatilization from there use as solvents.

The term BTEX reflects that benzene, toluene, ethylbenzene and xylenes are often found together.

## Health effects

Exposure to BTEX can occur by ingestion (consuming water contaminated with BTEX), inhalation (exposure to BTEX present in the air) or absorption through the skin. Inhalation of BTEX can occur while pumping or pouring gasoline or while using products containing the substance. Absorption of these chemicals can occur by spilling gasoline onto one's skin. Acute exposures to high levels of gasoline and its BTEX components have been associated with skin and sensory irritation, central nervous system depression, and effects on the respiratory system. According to the United States Environmental Protection Agency (USEPA), there is sufficient evidence from both human and animal studies to believe that benzene is a human carcinogen. Workers exposed to high levels of benzene in occupational settings were found to have an increased incidence of leukaemia. These levels are not likely to be reached in everyday events (cigarette smoking excluded), but are more likely from occupation-related exposures of duration and concentration.

## Summary of method

Passive absorption samplers that absorb the target gas into activated carbon and are subsequently analysed using gas chromatography, are employed to determine the average concentration of the gas in the air during the time of exposure. BTEX concentration is reported as µg/m$^3$ (mass of BTEX per volume of air).

## Guidelines

In New Zealand, benzene is the only member of the BTEX group subject to a national guideline value. The Ministry for the Environment guideline, based on benzene's known mutagenic and carcinogenic properties, is 3.6µg/m$^3$ as an annual average exposure There are no national ambient air quality guidelines for toluene, ethylbenzene or xylene.

The Ministry for the Environment had prepared an internal technical document "Health Effects of Eleven Hazardous Air Contaminants and Recommended Evaluation Criteria" (October 2000) that suggested a short-duration exposure threshold (1 hour average value) of 22 µg/m$^3$ for benzene, 500 µg/m$^3$ for toluene and 1000 µg/m$^3$ for xylene as recommended guidelines values. However, these recommendations were not carried through to the final Ministry for the Environment guidelines that were published in 2002.

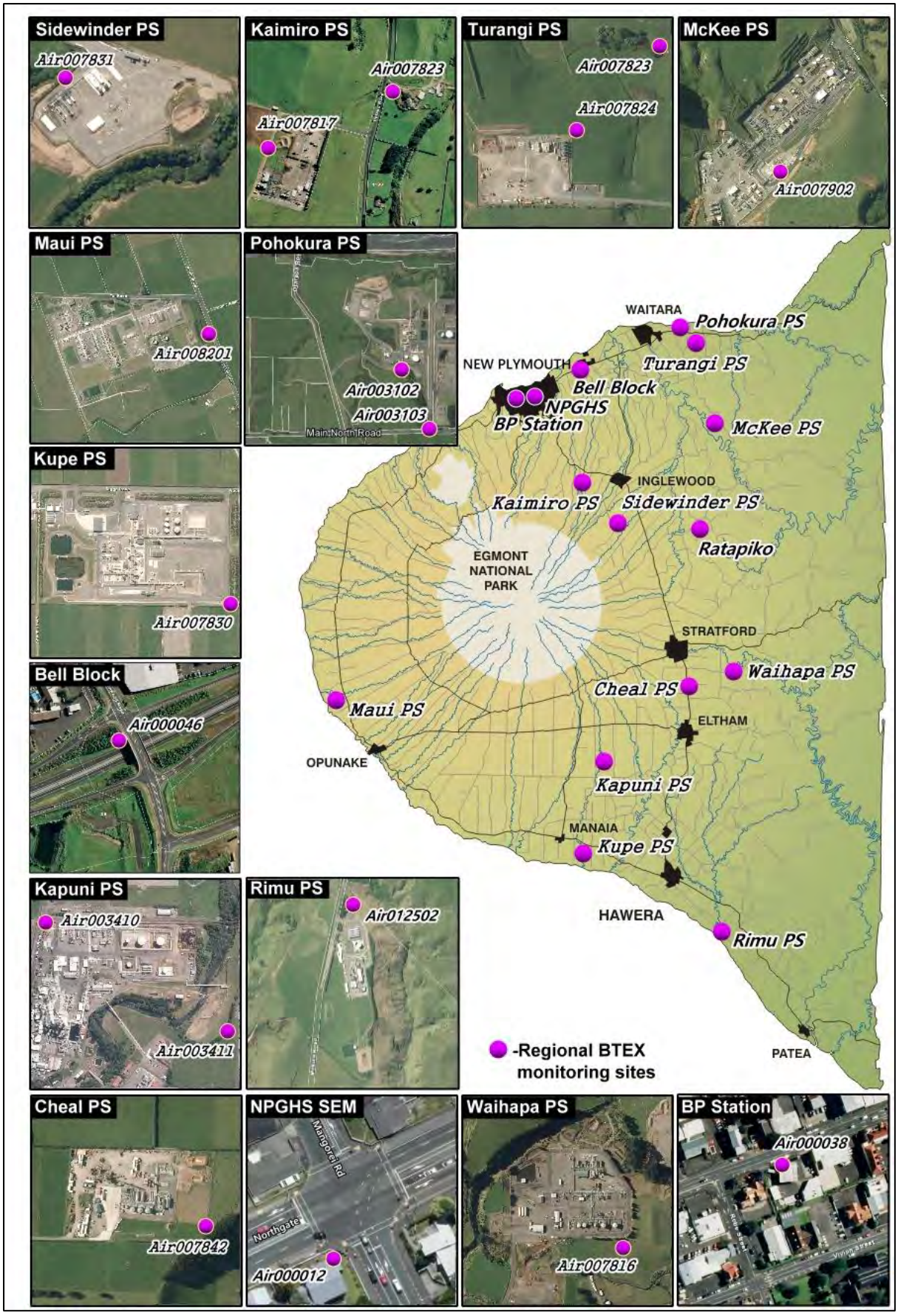


Figure 1 Regional BTEX monitoring sites 2019

## Results

The duration of sampling for VOCs was approximately 503 hours. The absorption activated carbon badge method provides an average concentration over the period of exposure. It does not provide a range (eg maximum or minimum concentrations) that may have occurred during the period of sampling.

The issue is therefore that of estimating an indicative equivalent exposure concentration over alternative time periods of interest (eg as referenced in guidelines or other criteria). For comparison with the Ministry for the Environment short-term guideline for BTEX, from the average concentration measured, it is desirable to consider what an indicative theoretical maximum one-hour concentration might be. There are mathematical equations used by air quality scientists to predict equivalent concentrations over varying time periods. These are somewhat empirical, in that they take little account of local topography, micro-climates, variations in activity processes, diurnal variation, etc. Nevertheless, they are conservative (they tend to over-estimate) and have some recognition of validity as a screening tool for a steady-state source. One formula in general use is of the form:

$$C(t_2) = C(t_1) \times \left(\frac{t_1}{t_2}\right)^P$$

where C(t) = the average concentration during the time interval t, and p = a factor lying between 0.17 and 0.20. When converting from longer time periods to shorter time periods, using p = 0.20 gives the most conservative estimate (i.e. the highest calculated result for time period t2 given a measured concentration for time period t1).

Using the 'worst case' factor of p = 0.20, the monitoring data reported herein have also been converted to equivalent 'maximum' one hour exposure levels. These should not be considered accurate estimates of what actually occurred, but can give an indication of any risk of exceedance of criteria.

The benzene results from this survey are also illustrated in Figure 2.

Table 1 Actual and recalculated (using a conversion factor of p=0.2) BTEX results around Taranaki region

| Site | Site ID / Where | Time total Min. | Benzene (µg/m³) | | Toluene (µg/m³) | | Ethyl Benzene | o,m,p – (µg/m³) Xylene Total | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Lab. Results | 1 hr. Calc. | Lab. Results | 1 hr. Calc. | Lab. Results | Lab. Results | 1 hr. Calc. |
| 1 | AIR000038 Petrol station | 503 | 182.48 | **633** | 8263 | **28,700** | 347 | 1401 | **4860** |
| 2* | AIR000012 NPGHS busy traffic intersection | 503 | 0.29 | 1.0 | 2.12 | 7.4 | 0.38 | 1.93 | 6.7 |
| 3 | AIR000046 B. Block SH3 | 503 | 0.32 | 1.1 | 1.23 | 4.3 | 0.23 | 0.70 | 2.4 |
| 4 | AIR003102 Pohokura PS | 502 | 6.59 | **23** | 3.23 | 11.2 | <0.19 | <0.43 | <1.5 |
| 5 | AIR003103 Pohokura SH3 | 502 | 1.17 | 4.1 | 0.80 | 2.8 | <0.19 | <0.43 | <1.5 |
| 6 | AIR007823 Turangi PS (House) | 502 | <0.15 | <0.5 | 0.55 | 1.9 | <0.19 | <0.43 | <1.5 |
| 7 | AIR007824 Turangi PS | 502 | 1.78 | 6.2 | 1.35 | 4.6 | <0.19 | <0.43 | <1.5 |
| 8 | AIR007902 McKee PS | 502 | 2.92 | 10.2 | 3.55 | 12.3 | 0.28 | 2.07 | 7.2 |
| 9 | AIR007831 Sidewinder PS | 502 | 5.71 | 19.8 | 12.27 | 42.6 | 0.77 | 20.56 | 71.3 |
| 10 | AIR007817 Kaimiro PS | 502 | 1.37 | 4.7 | 1.30 | 4.5 | 0.48 | 0.88 | 3.0 |
| 11 | AIR007846 Kaimiro PS (House) | 502 | <0.15 | <0.5 | 0.36 | 1.3 | <0.19 | <0.43 | <1.5 |
| 12 | AIR008201 Maui PS | 503 | 0.84 | 2.9 | 0.68 | 2.4 | <0.19 | <0.43 | <1.5 |
| 13 | AIR003410 Kapuni PS (NW) | 503 | 0.81 | 2.8 | 1.22 | 4.2 | <0.19 | 0.51 | 1.8 |
| 14 | AIR003411 Kapuni PS (SE) | 503 | 1.76 | 6.1 | 4.08 | 14.2 | <0.19 | 1.31 | 4.6 |
| 15 | AIR007827 Kupe PS (NW) | 503 | <0.15 | <0.5 | 0.30 | 0.04 | <0.19 | <0.43 | <1.5 |
| 16 | AIR007830 Kupe PS (SE) | 503 | <0.15 | <0.5 | 0.24 | 0.8 | <0.19 | <0.43 | <1.5 |
| 17 | AIR012502 Rimu PS | 503 | 1.25 | 4.3 | 0.85 | 2.9 | <0.19 | <0.43 | <1.5 |
| 18* | AIR007842 Cheal PS | 502 | 0.71 | 2.5 | 1.50 | 5.2 | <0.19 | 0.92 | 3.2 |
| 19 | AIR007816 Waihapa PS | 502 | 4.43 | 15.4 | 7.75 | 26.9 | <1.01 | 4.53 | 15.7 |
| 20 | AIR000051 Ratapiko (pristine) | 502 | 0.23 | 0.8 | 0.28 | 1.0 | <0.19 | <0.43 | <1.5 |
| Blank** | | | <0.15 | <0.5 | <0.2 | <0.7 | <0.19 | <0.4 | <1.5 |
| MfE recommended **guidelines** (2000), one -hour average. (µg/m³) | | | | **22** | | **500** | | | **1000** |

< = less than

2* and 18*: duplicate samplers were used

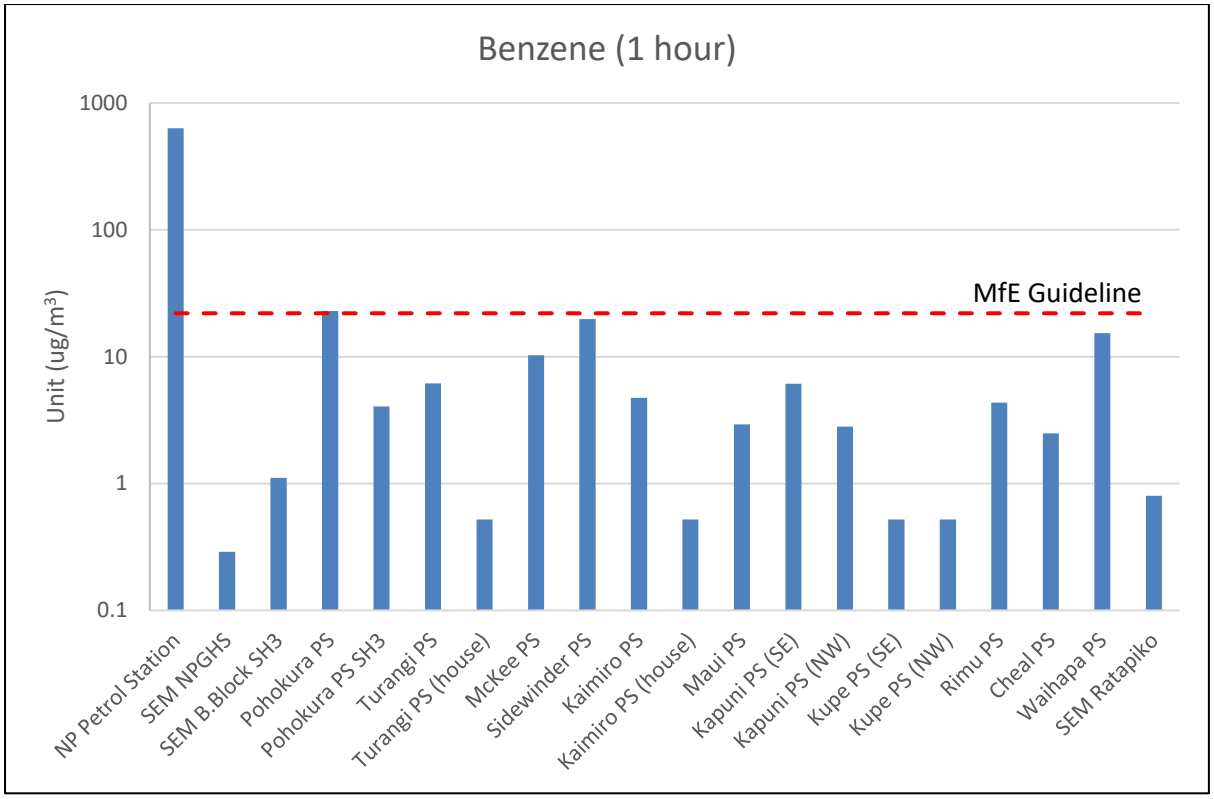


Figure 2 Regional benzene monitoring results 2019

## Discussion

The calculated 1-hour theoretical maximum concentrations of benzene (as estimated, using a power law exponent of 0.2 for the calculation) ranged from less than 0.5 µg/m³ to 633 µg/m³. The latter, significantly elevated result (633 µg/m³) was obtained within the premises of a functional urban petrol station. It should be noted that four of the 20 benzene results were 'less than' results, and further, that in all four cases the results show no difference to the result for the field blank. That is, there is no indication that benzene was actually detected at these four sites.

The results from monitoring of toluene, ethylbenzene and xylene have all been extremely low, other than for the urban petrol station at which high concentrations were obtained. As with the results for benzene, 14 results for ethylbenzene and ten results for xylene measurements were actually not detectable, at the limits of detection of the analytical method used. While the numbers given for each '<' (less than) result in the above table represent the maximum concentration that could have been present, the fact that these numbers do not differ from the analytical results of the blank (unexposed) sample suggests that any concentration of these gases is in fact equivalent to zero.

## Environmental Performance Indicator

Ministry for the Environment uses an environmental performance indicator to categorise air quality. These categories are set out in Table 2 and further details of the BTEX results are set out in Table 3. It should be noted that for the purpose of this comparison, 'less than' results have been deemed equivalent to their maximum possible value rather than considered as more or less equivalent to 'not present'.

Table 2 Environmental Performance Indicator air quality categories

| Measured value | Less than 10% of guideline | 10-33% of guideline | 33-66% of guideline | 66-100% of guideline | More than 100% of guideline |
|---|---|---|---|---|---|
| Category | *excellent* | *good* | *acceptable* | *alert* | *action* |

Table 3 Categorisation of results - Benzene (2019)

| **MfE guideline (2000) Benzene = 22 µg/m$^3$- 1 hour average.** | | |
|---|---|---|
| **Category** | **Measured values** | |
| Excellent | <10% of the guideline, (0-2.2µg/m$^3$) | **7** (35%) |
| Good | 10-33% of the guideline, (2.2-7.3µg/m$^3$) | **7** (35 %) |
| Acceptable | 33-66% of the guideline, (7.3-14.5 µg/m$^3$) | **2** (10%) |
| Alert | 66-100% of the guideline, (14.5-22 µg/m$^3$) | **2** (10%) |
| Action | Above 100% of the guideline (22 µg/m$^3$) | **2** (10%) |
| **Total number of samples** | | **20** (100%) |

The concentrations of toluene and xylene recorded in the current work were in exceedance of the ambient guideline values on one occasion at one monitoring site. This site was located on premises of the urban petrol station. The remaining 19 results reported were in the 'excellent' category of the Ministry's air quality category.

Two of the 20 benzene results were categorised into MfE's 'alert' category, and two in the 'action' category. For the latter, one sampling site was within an unused industrial property. The other result, which was also the highest recorded concentration for benzene, was obtained from the urban petrol station, where public exposure is typically for much less than one hour. Seventy percent of the benzene results were within 'excellent' and 'good' category of the Ministry's air quality category, with one slightly elevated result which fell into 'acceptable' category.