Cranfield University

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PhD Thesis

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Inlet monitoring of a potable water supply using a sensor array

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Abstract

Monitoring for pollutants in potable water is an area of interest and concern for water supply companies. Supply of sub-standard water can draw complaints from public and industrial consumers. Water and water tainted with pollutants were used to assess the application of a non-specific chemical sensor array (eNose) to monitor for changes in the headspace generated from a flow-cell by means of statistically designed experiments. 2-chlorophenol and diesel were used to further assess trends in headspace generation during trials where different combinations of sampling parameters were applied. Field trials were carried out at a drinking water abstraction facility. The trials were conducted in accordance with the most suitable methodology determined during initial studies under laboratory conditions.

The headspace is generated by bubbling nitrogen through the flow-cell containing a water sample. The liquid sample is flushed and regenerated after each sensor acquisition cycle. The resultant headspace sample is transferred to the sensor array module where the resistance of the conducting polymer sensors is monitored as they are exposed to each respective headspace sample. The change in each sensor resistance after 60 seconds of exposure is used to represent the headspace character. Subsequent acquisitions are added to a data set and then presented graphically. Sudden changes in the sensor resistance plots represent changes in water quality.

The results showed that the developed apparatus and sampling methodology can determine the presence or absence of pollution in a water matrix. Laboratory analysis showed that detection levels for 2-chlorophenol and diesel were both <5 ppm in the mixed stream. Future developments should focus on increasing the sensitivity of the system by concentrating the pollutants in either the liquid or gas phase or by modifying the sampling protocol to enable sensor recognition at lower concentration levels. The sensor array could act as a screening technique to support quantitative and characterising analytical equipment at the abstraction point. Establishing a pollution alarm limit, within the bounds

of acceptable system variation, would enable conventional analytical techniques to remain on standby until activated by a statistically significant change in water quality. Once established continued testing would enable alarm levels to be incorporated into a contaminant database for additional pollutant compounds and combinations of known taste and odour causing compounds.

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Dedication

For my Mum and Dad. There are times when 'thank you' just isn't enough.

"Until the 20th century reality was everything humans could touch, smell, see and hear. Since the initial publication of the charted electromagnetic spectrum, humans have learned that what they can touch, smell, see and hear is less that one millionth of reality" – Brandon Boyd.

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Chapter Two – Literature Review

List of Abbreviations

2-CP	2-chlorophenol	FET	Field effect transistor
2-MIB	2-methylisoborneol	FID	Flame ionisation detector
Ag	Silver	FPA	Flavour profile analysis
ANN	Artificial neural network	FTIR	Fourier transform Infrared spectrometry
BAW	Bulk acoustic wave	GAC	Granular activated carbon
CA	Cluster analysis	GC	Gas chromatograph
CCA	Canonical correlation analysis	In_2O_3	Indium oxide
CLSA	Closed loop stripping analysis	IR	Infra red
CO	Carbon monoxide	KG	Kilograms
CO_2	Carbon dioxide	KI	Potassium iodide
CP	Conducting polymer	Km	Kilometres
DAD	Diode array detection	LC	Liquid chromatography
DAEWS	Danube accident emergency warning system	LLE	Liquid-liquid extraction
ΔR	Change in sensor resistance	MDA	Multiple discriminant analysis
DI	De ionised water	Ml/min	Millilitres per minute
DM	Deutschemark	MOS	Metal oxide sensor
EA	Environment Agency	MOSFET	Metal oxide sensor field effect transistor
ECD	Electron capture detector	MS	Mass spectrometry
EtOH	Ethanol	MTBE	Methyl tert butyl ether
EU	European Union	N_2	Nitrogen
Fe	Iron	NOEC	No observed effect concentration

NTU	Nephelometric turbidity unit
OES	Optical emission spectrometry
Os	Osmium
OTC	Odour threshold concentration
PC	Personal computer
PCA	Principal component analysis
Pd	Palladium
pH	Potential hydrogen
PIAC	Principal international alert centre
PID	Photo-ionisation detector
PPB	Parts per billion
PPM	Parts per million
Pt	Platinum
QCM	Quartz crystal microbalance
R	Resistance
RH	Relative humidity
RO	Reverse osmosis
RPM	Revolutions per minute
SAMOS	System for the automated measurement of organic micropollutants in surface water
SAW	Surface acoustic wave
SD	Standard deviation
SE	Standard error
SnO_2	Tin oxide
SPE	Solid phase extraction
SPMD	Semi permeable membrane device
SPME	Solid phase micro extraction
TCD	Thermal conductivity detector
TCP	Trichlorophenol
TFN	Threshold flavour number
TID	Thermonic ionisation detector
TiO_2	Titanium dioxide
TOC	Total organic carbom
TON	Threshold odour number
UV	Ultra violet
Vs	Versus
WO_3	Tungsten oxide
Z	Statistical significance
ZnO	Zinc oxide

Publications and Conferences

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