

# 2019「中技社科技獎學金

2019 CICI Foundation Science and Iechnology Scholarship

### 境外经研究學会

Research Scholarship for International Graduate Students



## Environmental safety based on novel machine learning techniques and electrochemical sensors

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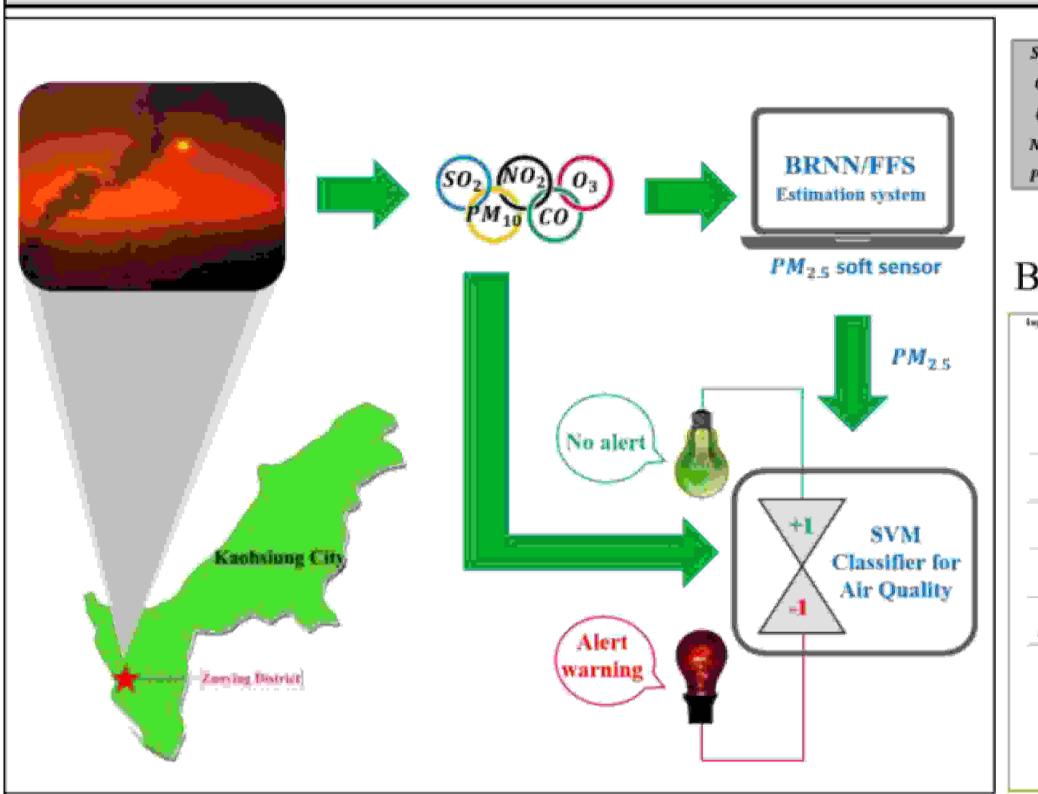
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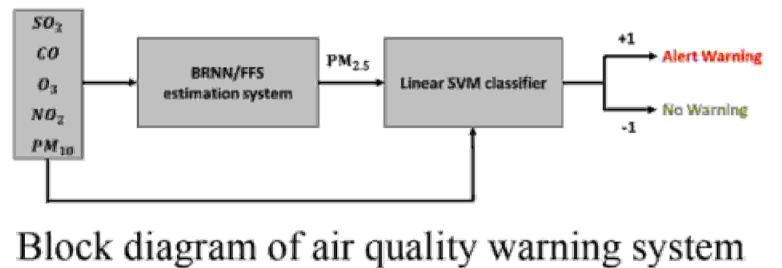
#### **Abstract**

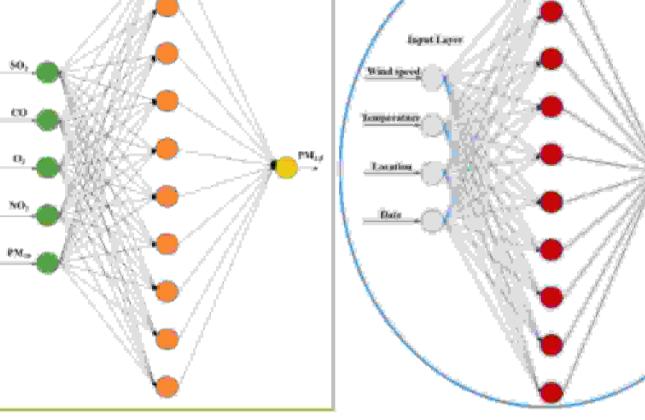
This research mainly focuses on development of advanced machine learning technologies and fabrication of electrochemical sensors for environmental safety. We have developed air quality warning systems based on PM<sub>2.5</sub> and ozone soft sensors using novel approach of Bayesian regularized neural network via forward feature selection and damped least squares neural network with greedy backward elimination respectively. These low cost and accurate monitoring systems and soft sensors can easily replace the existing expensive big instruments for air quality. Furthermore, we have fabricated electrochemical sensors for detection of water pollutants hydroquinone and nitrophenol.

#### Research Focus

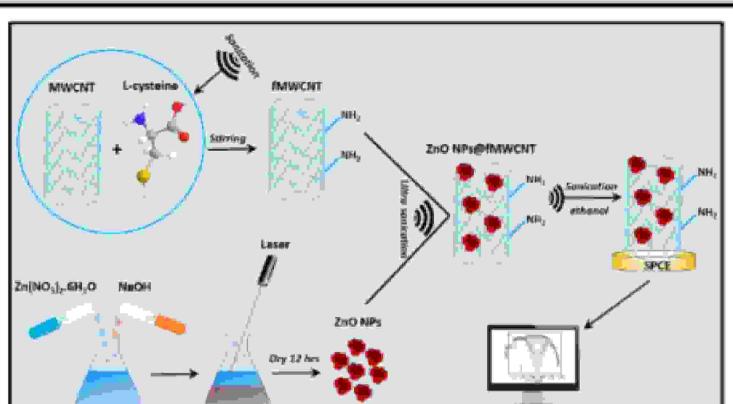


Graphical illustration of air quality warning system based on novel PM<sub>2.5</sub> soft sensor

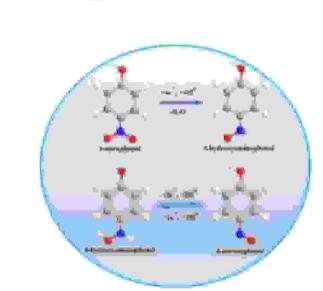




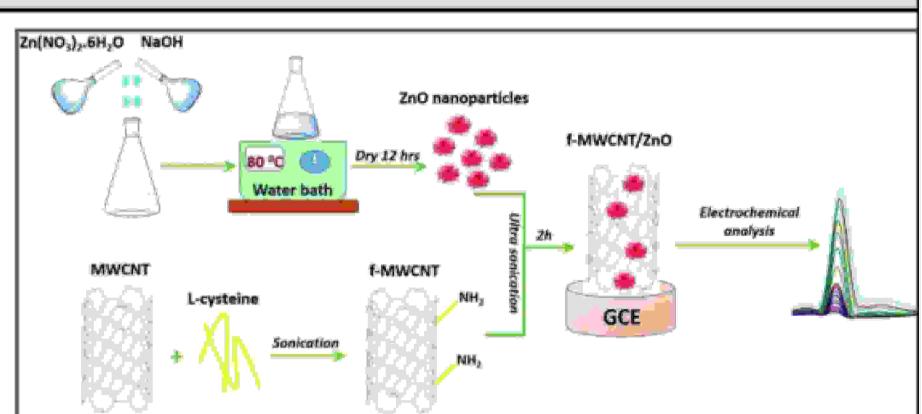
Architecture of BRNN Architecture of DLSNN estimation system estimation system



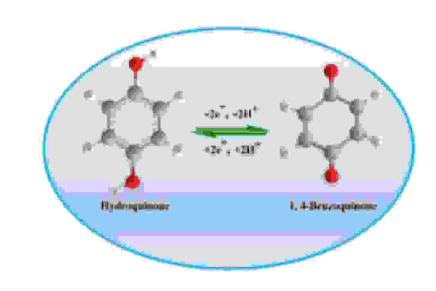
Schematic illustration of toxic 4-NP detection using ZnO NPs@fMWCNT nanocomposite



Electrochemical mechanism of 4-NP

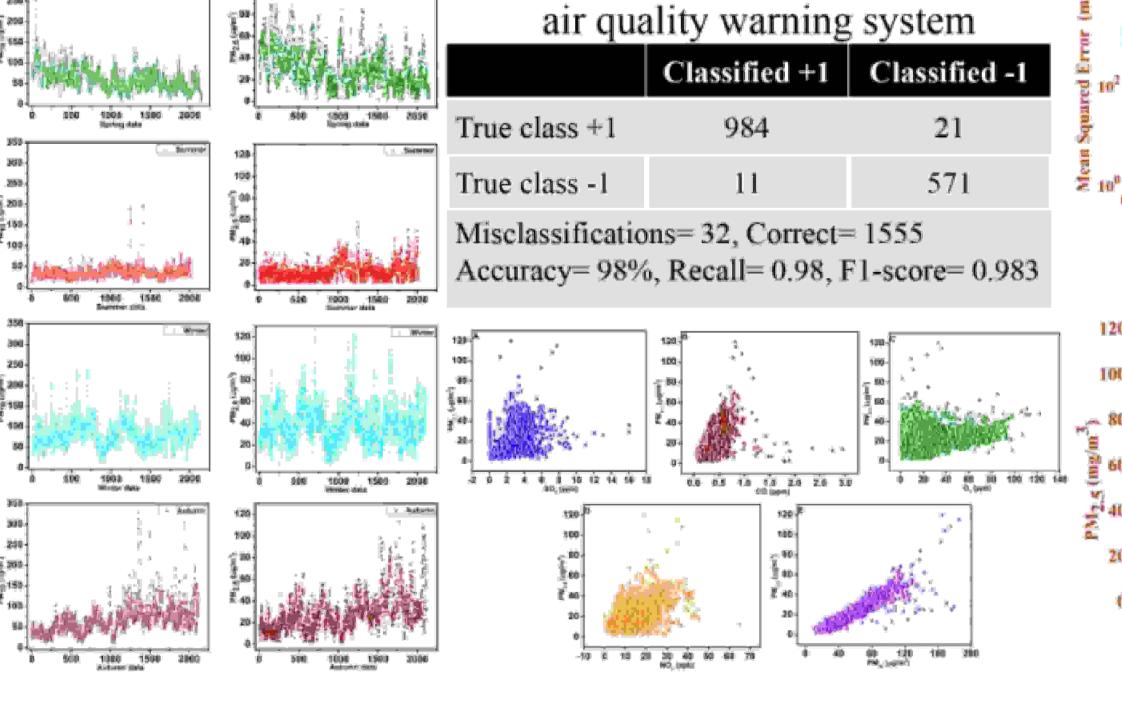


Schematic illustration of hazardous HQ detection using ZnO NPs@fMWCNT nanocomposite



Electrochemical mechanism of HQ

#### Research Results



Seasonal variations of particulate matter

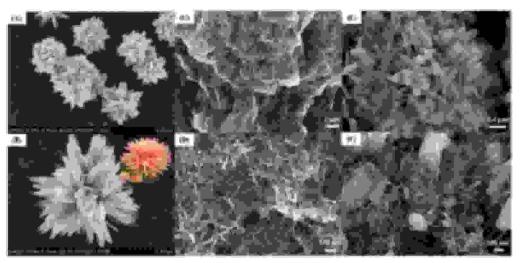
air pollutants towards PM<sub>2.5</sub>

Table 1: Performance evaluation of

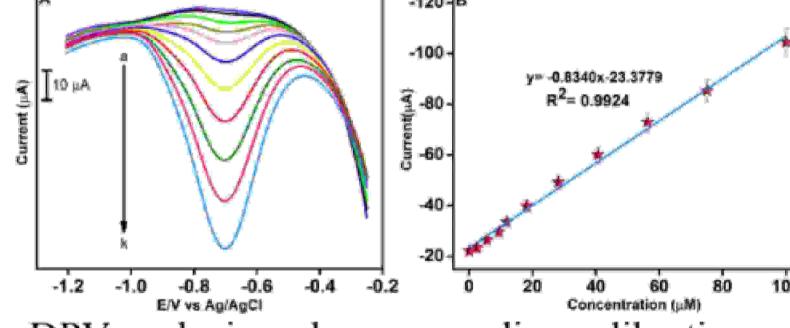
Estimated value vs True value Regression Curve

True Response Correlation analysis of various PM<sub>2.5</sub> soft sensor: (A)Performance graph, (B)Error histogram, (C)Estimated value vs true value, (D)Regression curve

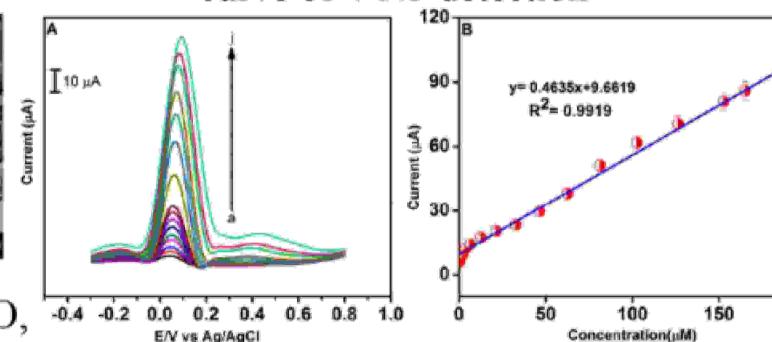
SEM of (A)3D flower ZnO, (B)fmwcnts, (C)ZnO/fmwcnts used for 4-NP detection



SEM of (A)ruskin michelle ZnO, (B)fmwcnts, (C)ZnO/fmwcnts used for 4-NP detection



DPV analysis and corresponding calibration curve of 4-NP detection



DPV analysis and corresponding calibration curve of HQ detection

#### Summary

- We have proposed novel methodologies including BRNN/FFS and DLSNN/GBE for development of PM<sub>2.5</sub> and ozone soft sensors for estimating pollutant concentrations.
- SVM and KNN classifiers are used for the development of warning systems based on PM<sub>2.5</sub> and ozone estimations respectively for attaining quick response.
- Descriptive statistics, seasonal variations, and correlation with various factors of particulate matter and ground-level ozone in Taiwan is evaluated as part of the research.
- All the performance metrics evaluated returned perfect results for the proposed air quality warning systems indicating its high efficiency.
- The fabricated 4-NP and HQ sensor exhibited excellent selectivity, good reproducibility, high stability, and repeatability which are the traits of a good electrochemical sensor.

#### Selected Journal Publications

- Balram Deepak, Kuang-Yow Lian, and Neethu Sebastian. "Air quality warning system based on a localized PM2. 5 soft sensor using a novel approach of Bayesian regularized neural network via forward feature selection." *Ecotoxicology and environmental safety* 182 (2019): 109386.
- Balram Deepak, Kuang-Yow Lian, and Neethu Sebastian. "Ultrasound-assisted synthesis of 3D flower-like zinc oxide decorated fMWCNTs for sensitive detection of toxic environmental pollutant 4-nitrophenol." *Ultrasonics sonochemistry* 60 (2020): 104798.
- Balram, Deepak, Kuang-Yow Lian, and Neethu Sebastian. "Synthesis of a functionalized multiwalled carbon nanotube decorated ruskin michelle-like ZnO nanocomposite and its application in the development of a highly sensitive hydroquinone sensor." *Inorganic Chemistry Frontiers* 5, no. 8 (2018): 1950-1961.

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