

A Pilot Study of an Online Intelligent Environmental Observation System for Monitoring and Evaluating Public Health Hazard from Indoor and Outdoor Pollutants

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Abstract: The overall aim of this research is the prevention of environmental risk and impact, through the establishment of a present-day environmental observatory centre, equipped with an intelligent monitoring, management and evaluating system. Detecting the environmental pollutants in a timely manner (forecasting), potentially related to adverse health effects while their frequency appears to have increased, shall contribute crucially to avoiding or reducing further inhabitants' exposure to pollutants in high environmental charging areas. A plurality of data will be collected and analyzed in the pilot Observatory. All these data will be gathered by measuring various environmental parameters (physicochemical, microbiological, ionized and not ionized radiation, dust, noise), a number of which will be transmitted wireless from small scale monitoring stations. The data base (territorial distribution of samples, number and frequency of sampling, analyze results, toxicity and risk indicators of environmental pollutants), will be enriched daily/weekly, with satellite data, meteorological data and satellite photographs (image analysis). With the collection, processing and analysis of measured values for various kinds of pollutants from environmental overloaded surfaces, useful conclusions are drawn regarding to the "pollution tendency" in every different area and the possible effects on human in combination with geography and geomorphology. With the use of artificial intelligence (AI) in human body simulators (whole body phantom models) we intend to make a more accurate qualitative and quantitative forecast: worst-best scenario, about as the life quality for residents -who may be exposed to the pollutants- as the direct or indirect medium to long-term adverse effects.

Keywords: Intelligent, Environmental, Observation, Health Hazard, Pollution

1. Introduction

As environmental pollution, is considered any natural quality deterioration of planet's natural elements as effect of human activities. The environmental threats at the health concern the pathogenic effects biological, chemical and natural factors. The environmental pollutants constitute a "chemical load" which human body cannot unload and does not the mechanisms in order to it can him degradation and him remove. The problem is the extremely difficult control of the pollutants. Many studies, associated with the environmental pollution and its negative impact on human health, have been conducted. These researches are related to

water bodies or water sources, air, soil, ionizing or non-ionizing radiation and health effects or risks of human exposure to pollutants. More specifically the overall methodology is categorized to:

1.1. Related Work for Air Pollution

The majority of the methods, referred in this study, investigate how the various airborne particulate matter (PM10, PM2.5, PM1) influence human health [1, 2, 5-7, 12-15, 18, 20, 22-24, 27, 29, 30, 32, 36]. Other methods show the contribution of air pollutant emissions caused by airport operations or deal with the impact of dust from quarrying on human health and well-being [10-11, 25, 32, 33]. There are

also methodologies for studying the health effects of African dust [6, 26]. Others investigate the particulate emissions during industrial fires [8]. Priority in our study are observing and monitoring air pollution based on innovative and state of the art monitoring and modelling methodologies [16, 17]. Finally, as is presented in Table 1, development of

appropriate integrated methodologies and software tools which aim to ensure the systematic and standardized assessment of the consequences of human health impact of exposure to chemicals and other physical and biological factors [2, 12-14, 19, 20, 22-26, 28-33, 35, 36].

Table 1. Literature review of methods related to air pollution.

a/a	Authors	Year	Title	Methodology & Results
1	Blades, E., Naidu, R. P., & Mathison, G. E.	1998	<i>The microbiological analysis of Sahara dust and its association with asthma in Barbados.</i> West Indian Med. J., 47 (suppl. 2), 34-5.	In this work investigation about the monthly variation of the concentration of Sahara dust in the atmosphere through the presence of micro-organisms in it. Important notice of the development of asthma than the concentration of the dust.
2	Eleftheria Chalvatzaki, Thodoros Glytsos & Mihalis Lazaridis	2015	<i>A methodology for the determination of fugitive dust emissions from landfill sites,</i> International Journal of Environmental Health Research 2015, Vol. 25, No. 5, 551–569	A new methodology for the determination of the contribution of fugitive dust emissions from landfill sites to ambient PM10 concentrations and the subsequent exposure to working personnel, that revealed that exposure to PM10, originating from fugitive dust emissions in the landfill site, was exceeding the health protection standards. The influence of the background concentration is estimated close to 23 %.
3	Ashok Kumar, Naveen K. Bellam, Anupma Sud	2004	<i>Performance of an industrial source complex model: Predicting long - term concentrations in an urban area,</i> Environmental Progress 2004, Vol. 18. Issue 2, pp. 93-100	In this work the ISCST3 and ISCLT3 models were used to predict monthly and quarterly averages of sulfur dioxide concentrations are evaluated for estimating long - term concentrations using sulfur dioxide data from emission inventory of Lucas County, Ohio for the year 1990. The study suggests that the ISCST3 model is better for estimating long - term concentrations of sulfur dioxide as compared to the ISCLT3 model.
4	Victoria Aleksandropoulou & Mihalis Lazaridis	2013	<i>Development and application of a model (ExDoM) for calculating the respiratory tract dose and retention of particles under variable exposure conditions.</i> Air Qual Atmos Health (2013) 6: 13–26.	The ExDoM is the model that incorporates an exposure module which allows the user to set variable or static exposure conditions (exposure concentration, physical exertion levels, and different environments) or in the case of the physical exertion levels and exposure environment to choose from a list of typical exposure scenarios (activity pattern, exposure environment, and physical exertion level). After the use of ExDOM, results showed that the dose was enhanced for the carbonaceous fine fraction of particles in the alveolar region of the lung whereas the dose of crustal material dominated in the extrathoracic region.
5	Simon D. Griffiths et al.	2018	<i>A study of particulate emissions during 23 major industrial fires: Implications for human health,</i> Environment International 2018, Vol. 112, pp. 310–323.	In this context, 'indicative' is applied to monitoring equipment that provides confirmation of the presence of particulates and indicates a measured mass concentration value. In conclusion AQinMI is a positive development, there is a need to consider further the accuracy of the data provided and for the successful development of a very short-term guideline values (i.e. minutes to hours) that responders can use to determine the appropriate public health response
6	K. Gyan et al.	2005	<i>African dust clouds are associated with increased paediatric asthma accident and emergency admissions on the Caribbean island of Trinidad,</i> Int J Biometeorol (2005) 49: pp. 371–376	In this work a Poisson regression model was used to determine the statistical relationship between acute paediatric asthma A&E visits and Saharan dust cover with and without other variables such as climatic parameters and month. The best fitting model estimated that in one month, such as June, a deterioration of visibility due to increased Saharan dust cover from no dust (visibility =16 km) to very dusty (visibility =7 km) would increase a daily admission rate of 7.8 patients to 9.25 when climate variables such as barometric pressure and humidity were kept constant
7	Chiang C, Lai C, Chou P, Li Y, and Tu Y.	1999	<i>ASIA - PACIFIC Conference on the Built Environment. The Study On The Comprehensive Indicators Of Indoor Environment Assessment For Occupants' Health.</i> (Taipei, Taiwan) pp 1–7	This study describes the methodology of the indoor environment assessment on existing buildings and intends to draft indoor-environment preservation indicators, including acoustics, vibration, illumination, thermal comfort, indoor air quality and electromagnetic environment. It's necessary to take various aspects of the environmental factors into consideration, when dealing with the influence of built-environment on tenants
8	W H W Ibrahim1, E Marinie, J Yunus, N Asra and K Mohd Sukor,	2018	<i>Air quality assessment on human well-being in the vicinity of quarry site,</i> IOP Conf. Series: Earth and Environmental Science 117 (2018) 012010	Air pollutants were monitored with the use of instruments which are Rae System Multirae Lite Pumped (PGM-6208) to measure indoor air quality while TSI 8533 Dusttrack Drx Desktop Aerosol Monitor to measure outdoor air quality. In this work sampling was replicated two times. According to this paper it is not only presents the beneficial information for future research on methodologies

a/a	Authors	Year	Title	Methodology & Results
9	Athanasios Valavanidis Konstantinos Fiotakis and Thomais Vlachogianni	2008	<i>Airborne Particulate Matter and Human Health: Toxicological Assessment and Importance of Size and Composition of Particles, for Oxidative Damage and Carcinogenic Mechanisms</i> , Journal of Environmental Science and Health Part C (2008), 26: pp. 339–362.	employed but also it is anticipated the benefit to environment which can increased residents' well-being in the vicinity of quarry sites The evaluation of most of similar studies shows that the smaller the size of PM the higher the toxicity through mechanisms of oxidative stress and inflammation. In this work associations between chemical compositions and particle toxicity tend to be stronger for the fine and ultrafine PM size fractions. Vehicular exhaust particles are found to be most responsible for small-sized airborne PM air pollution in urban areas This study used data from 1533 adults from two multicentre cohorts' studies (EGEA and ECRHS). Rhinitis incidence was defined as reporting rhinitis at the second follow-up (2011 to 2013) but not at the first follow-up (2000 to 2007). Incidence rate ratios (IRR) were computed using Poisson regression. Pooled analysis, analyses by city and meta-regression testing for heterogeneity were carried out. This study did not find any consistent evidence of an association between long-term air pollution and incident rhinitis.
10	E. Burte et al.	2018	<i>Association between air pollution and rhinitis incidence in two European cohort</i> , Environment International 115 (2018) 257–266	According to this work sources relevant to air quality include not only engine exhaust and non-exhaust emissions from aircraft, but also emissions from the units providing power to the aircraft on the ground, the traffic due to the airport ground service, maintenance work, heating facilities, fugitive vapours from refuelling operations, kitchens and restaurants for passengers and operators, intermodal transportation systems, and road traffic for transporting people and goods in and out to the airport. An overview of other additional sources within airports is provided.
11	Mauro Masiol, Roy M. Harrison	2014	<i>Aircraft engine exhaust emissions and other airport-related contributions to ambient air pollution: A review</i> , Atmospheric Environment 95 (2014) 409-455.	In this paper, road dust collected in the Venice international airport is characterized with a multi-technique approach in order to identify the main pollutant sources and to highlight the differences between airside/landside places. The most polluted sites are identified and a preliminary risk assessment is performed taking into account ingestion, dermal intake and inhalation of fugitive particulate pathways. Results confirmed that streets are the most polluted landside places; while road dust of airside area is significantly more concentrated in PAHs, Na, Al, Cu, Zn, Ag, Cd. Finally, as regards the risk assessment, the most critical pollutants (in concern order) are: As, BaP, Cr, Sb, BaA, and BbF.
12	G. Valotto et al.	2018	<i>Characterization and preliminary risk assessment of road dust collected in Venice airport (Italy)</i> , Journal of Geochemical Exploration 190 (2018) pp. 142–153	MODIS aerosol retrievals provide useful perspective to the global air pollution. The three case studies in northern Italy, Los Angeles, and Beijing demonstrated the MODIS capability for monitoring regional and local air pollution. In this work an approach with Terra and Aqua MODIS direct broadcasting (data processing time <1 hour), the near real time (twice a day) monitoring of air pollution is possible in any places around the world. Today's measurements in the eastern United States and western Europe comparing to eastern China and India suggest the results of reduced air pollution level because of continuous governmental clean - air activities
13	Chu et al.	2003	<i>Observing System-Terra Moderate Resolution Imaging Global monitoring of air pollution over land from the Earth Spectroradiometer (MODIS)</i> , J. Geophys. Res., Vol. 108 (D21), 4661 (2003)	In this study UAVs are guided by proposed Pollution-driven UAV Control (PdUC) algorithm, which is based on a chemotaxis metaheuristic and a local particle swarm optimization strategy and automatically performing the monitoring of a specified area using UAVs. Experimental results show that, when using PdUC, an implicit priority guides the construction of pollution maps by focusing on areas where the pollutants' concentration is higher. Finally accurate maps can be constructed in a faster manner when compared to other strategies.
14	Oscar Alvear, Nicola Roberto Zema, Enrico Natalizio, and Carlos T. Calafate	2017	<i>Using UAV-Based Systems to Monitor Air Pollution in Areas with Poor Accessibility</i> , Journal of Advanced Transportation Volume 2017, Article ID 8204353, 14 pages	According to this review the relevant terminology and processes proposed in the literature explain the interfaces and interactions between atmospheric particles and human body within the framework of "atmospheric particle cycles." In this work authors claim that there is an urgent need for a standard protocol or speciation methods applicable to earth-materials to guide and streamline studies on aetiology of mineral-induced diseases. This
15	N. S. Duzgoren-Aydin	2008	<i>Health Effects of Atmospheric Particulates: A Medical Geology Perspective</i> , Journal of Environmental Science and Health Part C, 26: 1–39, 2008.	

a/a	Authors	Year	Title	Methodology & Results
16	L. M. Filimonova, A. V. Parshin V. A. Bychinskii	2015	<i>Air pollution assessment in the area of aluminum production by snow geochemical survey</i> , Russian Meteorology and Hydrology October 2015, Volume 40, Issue 10, pp 691–698	protocol or speciation methods should provide relevant procedures to determine the level and extent of physical, chemical and mineralogical heterogeneity of particulate matters as well as quantitative in-situ particulate characteristics. In this work the monitoring of the snow cover was conducted in the zone of the impact of the emission source (the Irkutsk Aluminium Smelter). The population of the town of Shelekhov will probably suffer from chronic diseases of the respiratory system. The dust-aerosol pollution of the Shelekhovskii industrial region forms the specific lithochemical anomaly with the area of about 70 km ² . Its central part adjoins the Irkutsk Aluminium Smelter. The anomaly is represented by the set of litho-, chalc-, and siderophile elements forming contrast (relative to the background areas) associations.
17	Zhenxv Lan, Fengyuan Zhang, Jia Wang, Min Chen	2018	<i>Design and Implementation of a Dynamic Simulation System for Air Pollutant Diffusion - A Case Study of the Fangshan District, Beijing, China</i> , J Geol Geosci Volume 2 (1): 2018	In this study a simulation system platform for the diffusion process of atmospheric pollutants is designed and implemented, which has various functions including dynamic simulation display expression, GIS spatial analysis, spatial data processing, attribute information extraction and simulation result thematic mapping and export. The results show that the system provides significant decision-making guidance for effective urban air pollution warnings and the improvement of urban air quality
18	D. Briggs et al.	1997	<i>Mapping urban air pollution using GIS: a regression-based approach</i> , Journal International Journal of Geographical Information Science Volume 11, 1997 - Issue 7	In this study to determine the chemical composition of pollutants and the distance of their propagation on the territory under study in 2013 and 2014, data from 80 of the monitoring sites were then used to construct a regression equation, on the basis of predictor environmental variables, and the resulting equation used to map air pollution across the study area. Results showed that the map produced extremely good predictions of monitored pollution levels, both for individual surveys and for the mean annual concentration. Though the accuracy of predictions for individual survey periods was more variable..
19	H. Catherine W. Skinner	2007	The earth, source of health and hazards: An introduction to medical geology. Annual Review of Earth and Planetary, Sciences 2007; 35: 177–213	Geographical Information Systems (GIS) has become the technique with which geochemical and surficial topographic and any other geologic data can be linked to epidemiological data on disease and its distribution. Health impacts depend on bioavailability of hazardous materials or agents and their transfer to or into the human body. According this work the many and diverse human responses to different levels of chronic hazards plus patchy reporting of disease occurrences for individuals, communities, and countries limit the data available for constructing models capable of predicting thresholds or exposure levels to chronic hazards for an at-risk group of individuals or populations
20	X. Peng et al.	2016	<i>Influence of quarry mining dust on PM_{2.5} in a city adjacent to a limestone quarry: Seasonal characteristics and source contributions</i> , Science of the Total Environment 550 (2016) pp. 940–949	In this study the samples were subject for chemical analysis for dust-related species (Al, Si, Ca, Fe, Ti), tracer metals, carbon components and water-soluble ions. Seasonal variations of PM _{2.5} and its main chemical components were investigated. Air mass residence time (AMRT) analysis showed that northeast and southeast regions might be the major PM _{2.5} source during the sampling campaign. The findings of this study can be used to understand the characteristics of quarry mining dust and control strategies for PM _{2.5} .
21	Inmaculada Menendez et al.	2017	<i>Saharan dust and the impact on adult and elderly allergic patients: the effect of threshold values in the northern sector of Gran Canaria, Spain</i> , International Journal of Environmental Health Research, 2017, 27: 2, 144–160	During 2010 and 2011, an epidemiological survey, in parallel with an air quality study, was conducted at the Dr Negrín hospital in Gran Canaria. In this study no statistically significant relations were found between the allergic control group, the emergency room admissions, pulmonary conditions, medication, and elevated Saharan dust levels
22	Yong Zha, Jay Gao, Jianjun Jiang, Heng Lu & Jiazhu Huang	2012	<i>Normalized difference haze index: a new spectral index for monitoring urban air pollution</i> . International Journal of Remote Sensing, Vol. 33, No. 1, 10 January 2012, pp. 309–321	A new index called the normalized difference haze index (NDHI) was derived using moderate resolution imaging spectroradiometer (MODIS) data from winter 2008–2009 and in this study it was concluded that NDHI is a reliable indicator of air pollution. It can be used as a new method of effectively monitoring air pollution from remotely sensed data.
23	L. Risom et al.,	2005	<i>Oxidative stress-induced DNA damage</i>	There is overwhelming evidence from animal experimental

a/a	Authors	Year	Title	Methodology & Results
			<i>by particulate air pollution, Mutation Research 592 (2005) pp. 119–137</i>	models, cell culture experiments, and cell free systems that exposure to diesel exhaust and diesel exhaust particles causes oxidative DNA damage. In this study oxidative stress-induced DNA damage appears to an important mechanism of action of urban particulate air pollution. Related biomarkers and personal monitoring may be useful tools for risk characterization.
24	C. A. Pope III, R. T. Burnett, M. J. Thun, E. E. Calle, D. Krewski, K. Ito, G. D. Thurston	2002	<i>Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution, JAMA 287 (2002) pp. 1132–1141</i>	The analysis is based on data collected by the American Cancer Society (ACS) as part of the Cancer Prevention Study II (CPS-II), an ongoing prospective mortality study of approximately 1.2 million adults. 18, 19 Individual participants were enrolled by ACS volunteers in the fall of 1982. Participants resided in all 50 states, the District of Columbia, and Puerto Rico, and were generally friends, neighbors, or acquaintances of ACS volunteers. The findings of this study provide the strongest evidence to date that long-term exposure to fine particulate air pollution common to many metropolitan areas is an important risk factor for cardiopulmonary mortality. Elevated fine particulate air pollution exposures were associated with significant increases in lung cancer mortality.
25	B. Brunekreef, S. T. Holgate	2002	<i>Air pollution and health, Lancet 360 (2002) pp. 1233–1242.</i>	Exposure to pollutants such as airborne particulate matter and ozone has been associated with increases in mortality and hospital admissions due to respiratory and cardiovascular disease. These effects have been found in short-term studies, which relate day-to-day variations in air pollution and health, and long-term studies, which have followed cohorts of exposed individuals over time.
26	T Bellander et al.	2001	<i>Using geographic information systems to assess individual historical exposure to air pollution from traffic and house heating in Stockholm, Environmental Health Perspectives • VOLUME 109 NUMBER 6 June 2001</i>	In this study data collected for 1,042 lung cancer cases and 2,364 population controls included information on residence from 1955 to the end of follow-up for each individual, 1990–1995. Assessed ambient air concentrations of pollutants from road traffic and heating throughout the study area for three points in time (1960, 1970, and 1980) using reconstructed emission data for the index pollutants nitrogen oxides (NOx/NO2) and sulfur dioxide together with dispersion modeling. The results indicate that GIS can be useful for exposure assessment in environmental epidemiology studies, provided that detailed geographically related exposure data are available for relevant time periods
27	S. L. Penn et al.	2017	<i>Modeling variability in air pollution-related health damages from individual airport emissions, Environmental Research 156 (2017) pp. 791–800</i>	Modelling concentrations of fine particulate matter (PM2.5) and ozone (O3) attributable to precursor emissions from individual airports in the United States, developing airport-specific health damage functions (deaths per 1000t of precursor emissions) and physically-interpretable regression models to explain variability in these functions. In this study authors applied the Community Multiscale Air Quality model using the Decoupled Direct Method to isolate PM2.5- or O3-related contributions from precursor pollutants emitted by 66 individual airports. Findings reinforce the importance of location- and source-specific health damage functions in design of health-maximizing emissions control policies.
28	Jerrett, M. et al.	2009	<i>Long-term ozone exposure and mortality. New Engl. J. Med. 360 (11), 1085–1095</i>	In this study, data from the study cohort of the American Cancer Society Cancer Prevention Study II were correlated with air-pollution data from 96 metropolitan statistical areas in the United States. Data were analyzed from 448,850 subjects, with 118,777 deaths in an 18-year follow-up period. Associations between ozone concentrations and the risk of death were evaluated with the use of standard and multilevel Cox regression models. In this large study, was not able to detect an effect of ozone on the risk of death from cardiovascular causes when the concentration of PM2.5 was taken into account. sure to ozone on the risk of death from respiratory causes.
29	Brook, R. D.	2002	<i>Inhalation of fine particulate air pollution and ozone causes acute arterial vasoconstriction in healthy adults. Circulation 105 (13), pp 1534–1536.</i>	Twenty-five healthy adults underwent a randomized, double-blind, crossover study comparing the vascular response to the 2-hour inhalation of approximately 150 microg/m (3) of concentrated ambient fine particles (CAP) plus ozone (120 ppb) versus the response to the inhalation of filtered airShort-term inhalation of fine particulate air pollution and ozone at concentrations that occur in the urban environment causes acute conduit artery vasoconstriction

a/a	Authors	Year	Title	Methodology & Results
30	Colin Wong and Rachel Wyles	2012	<i>Mapping concentrations of airborne matter to quantify the fugitive emissions discharge rate from a landfill</i> , Greenhouse Gas Measurement & Management 2 2012 50–60	In this work the application of the AMM method involved the measurement of wind velocity at the site, mounting a GPS and a fast, high-resolution concentration measurement instrument on a helicopter and then travelling through the plume along a measurement path, with each sampling run at different elevations, was conducted. The methane concentration data were also projected with the wind flow direction onto a flux plane and, when the wind speed was applied and an adjustment made for the background concentrations, the net mass flow rate of methane across the measurement surface and the mass emission discharge rate from the fugitive emission source were calculated to be 2.3 g/s.

1.2. Related Work for Surface and Underground Water Bodies

The majority of the methods reviewed in the present study refer to monitoring, sampling and measuring of fertilizers, pesticides, insecticides [3, 37, 52–54, 57, 60, 61] as is presented in Table 2. There are also scientific articles and

research data which make reference to industrial effluents, waste water and solid waste treatment monitoring [39–50, 71–77]. Other methods of sampling techniques and analysis for the monitoring of water bodies focus on the chemical elements (Emergent Contaminants ECs) [3, 4, 50–61, 65–70, 78–81].

Table 2. Literature review of methods related to water bodies.

a/a	Authors	Year	Title	Methodology & Results
1	Iturburu, F. G., Calderon, G., Amé, M. V., & Menone, M. L.	2019	<i>Ecological Risk Assessment (ERA) of pesticides from freshwater ecosystems in the Pampas region of Argentina: Legacy and current use chemicals contribution</i> . Science of The Total Environment, 691, 476–482.	Based on a concentration addition model, this study developed an Ecological Risk Assessment (ERA) of pesticides from freshwater ecosystems in the Pampas region. For this purpose, reported pesticides concentrations available in public bibliography and a Risk Quotients (RQs) approach were used. A cumulative risk map was established to display RQs for current use pesticides (CUPs) and legacy chemicals. The present study is the first attempt to develop an ERA in surface water of the Pampas region of Argentina and it provides a starting point for a more comprehensive pesticides monitoring and a further risk assessment program.
2	Boone, J. S., Vigo, C., Boone, T., Byrne, C., Ferrario, J., Benson, R.,... & Glassmeyer, S. T.	2019	<i>Per- and polyfluoroalkyl substances in source and treated drinking waters of the United States</i> . Science of the Total Environment, 653, 359–369.	During this work seventeen per- and polyfluoroalkyl substances (PFAS) were monitored by LC/MS/MS. Twenty-five paired source and treated drinking waters were sampled. All 50 samples had detectable PFAS; one exceeded health advisory guidelines. Distinctive PFAS patterns were observed for two large river systems. The perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) concentrations in the treated drinking water are compared to the existing US Environmental Protection Agency's PFOA and PFOS drinking water health advisory of 70 ng/L for each chemical or their sum one DWTP exceeded the threshold. Six of the 25 DWTPs were along two large rivers. The DWTPs within each of the river systems had specific PFAS profiles, with the three DWTPs from one river being dominated by PFOA, while three DWTPs on the second river were dominated by perfluorobutyric acid (PFBA). A total of 416 samples were collected over a 1.5-year sampling period (September 1999– February 2001) from six rivers and ten lakes, in the present work. The water samples were analyzed with an off-line solid phase extraction technique coupled with a gas chromatography ion trap mass spectrometer using an analytical method for 147 pesticides and their metabolites, including organochlorines, organophosphates, triazines, chloroacetanilides, pyrethroids, carbamates, phthalimides and other pesticides (herbicides, insecticides and fungicides). Based on the pesticide survey results, a human health carcinogenic and non-carcinogenic risk assessment was conducted for adults and children. Concentrations of six pesticides were above the maximum allowable limit of 0.1 µg/L set for drinking water. The coupling of monitoring data to probabilistic human and ecotoxicological risk estimates could find use by Greek regulatory authorities, proposing effective pollution management schemes.
3	E. N. Papadakis et. al.	2015	<i>A pesticide monitoring survey in rivers and lakes of northern Greece and its human and ecotoxicological risk assessment</i> , Ecotoxicology and Environmental Safety 116 (2015) 1–9	The main objective of this study was to investigate the effect on water quality of Sembilang River that receives effluent from the nearby landfill. In this study. Samples of water from ten sampling stations starting from the upstream to downstream of Sembilang River, were analyzed. The water quality was evaluated by the Water Quality Index (WQI) depending on in-situ and laboratory analysis. 11 water quality variables are selected for the quality assessment; temperature, pH, turbidity, salinity, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, total suspended solid, ammoniacal
4	Tengku Ibrahim, F. Othman and N. Z. Mahmood	2017	<i>Assessment of water quality of Sembilang River receiving effluent from controlled municipal solid waste (MSW) landfill in Selangor</i> , IOP Conf. Series: Materials Science and Engineering 210 (2017) 012019	

a/a	Authors	Year	Title	Methodology & Results
5	Ujjianti, R. M. D., Anggoro, S., Bambang, A. N., & Purwanti, F.	2018	<i>Water quality of the Garang River, Semarang, Central Java, Indonesia based on the government regulation standard. In Journal of Physics: Conference Series (Vol. 1025, No. 1, p. 012037). IOP Publishing</i>	nitrogen, phosphate and nitrate. The result indicated that, when the effluent mixed with the river water, the water quality decreased gradually and was found to be lower at a few stations. The water quality of Sembilang River falls under Class III of Water Quality Index with ranges between 68.03 to 43.46 mg/L. It is revealed that the present scenario of water quality of Sembilang River is due to the effect of effluent from the landfill. This study aimed to analyse water quality of the Garang river using pollution index based on the government regulation. Series data from 2010 to 2016 were derived from the Environmental and Forestry Office of the Central Java Province and sampling of water quality was taken in August 2017 from the middle of watershed area. Water quality parameters include temperature, pH, TDS, DO, COD, Phosphate, Nitrate, Chromium, Copper, Cadmium and H ₂ S. It was revealed that concentration of Copper has exceeds the standard of the Government Regulation No. 82 Year 2001. The water pollution index showed that the river is lightly polluted. Therefore the river should be managed comprehensively for sustainable uses in order to create one river one management concept.
6	A. Allahyar and M. R. Sabour M R (2014),	2014	<i>Multi-response optimization of Fenton process for applicability assessment in landfill leachate treatment, Waste Management 34 2528-2536.</i>	In this study, the response surface methodology was applied for the modeling and optimization of Fenton process in three target responses, (1) overall COD removal, (2) sludge to iron ratio (SIR) and (3) organics removal to sludge ratio (ORSR), where the latter two were new self-defined responses for prediction of sludge generation and applicability assessment of the process, respectively. It was found that all the variables had significant effects on the responses, specifically by their observed role in dominant oxidation mechanism. Finally, it was observed that [H ₂ O ₂]/[Fe ²⁺] ratio and Fe ²⁺ dosage had significant influence on COD removal, while Fe ²⁺ dosage and [H ₂ O ₂]/[Fe ²⁺] ratio had remarkable effects on SIR and ORSR responses, respectively. Leachate volumes have been quantified using two different approaches, namely the hydraulic evaluation of landfill performance (HELP) model and the water balance method (WBM), and then compared with the measured quantities by the landfill's management in the present work. Results of the HELP model showed that the average annual generated leachate volumes were 8,087 m ³ from 1997 to 2014, while the average annual percolated leachate volumes were 717 m ³ , which represented 8.9% of the generated leachate amounts. The landfill's leachate was mainly originated from the moisture content of the dumped wastes, whereas the rest came from the infiltration of the rainfall and re-circulated leachate. The cumulative modelled leachate amounts by HELP model and WBM were close, and with a difference percentage of 6.6%. However, both methods' results were higher than the measured leachate amounts. In conclusion, suitable mitigation measures are required to minimise the potential threats on to groundwater due to leachate percolation
7	Abunama, T., Othman, F., Alsiaibi, T., & Abualqumboz, M.	2017	<i>Quantifying the Generated and Percolated Leachate through a Landfill's Lining System in Gaza Strip, Palestine. Polish Journal of Environmental Studies, 26 (6)</i>	This study was conducted to assess the capacity and efficiency of Pennisetum clandestinum, a prostrate perennial plant, to accumulate chromium (Cr), copper (Cu), iron (Fe), nickel (Ni), zinc (Zn) and lead (Pb). Leachate, taken from the Sofulu Landfill Site, was given to Pennisetum clandestinum for 180 days, in 3 dilution sets as 1/1, 1/2 and 1/4, in batch configuration. An additional control set was also installed for comparison. Results showed that, even though the metal content of soil had risen, plants accumulated 2 to 8.5 times higher concentrations than the control set. It is important to see, the plant showed almost no stress symptoms even if the set was fed by pure leachate. Pennisetum clandestinum was observed to accumulate metals mostly in the upper bodies, excluding Fe and Cu. 76% of accumulated Cr, 85% of Ni, 66% of Zn and 100% of Pb was observed to accumulate in above-ground parts, where only 20% of Cu and 4% of Fe was accumulated. Due to the high pollution tolerance of Pennisetum clandestinum, makes this plant suitable for decontamination and remediation of landfill sites
8	D. L. Jones, K. L. Williamson and A. G. Owen	2006	<i>Phytoremediation of landfill leachate, Waste Management 26 825-837</i>	An effective removal method for PFCs and other polar and persistent compounds from landfill leachates has been a major challenge, since commonly used treatment technologies are based on aeration and sedimentation. Thus, the present study has shown that municipal landfill leachates may represent a significant source of concern for legacy, new and emerging chemicals in groundwater.
9	T. Eggen, M. Moeder and A. Arukwe	2010	<i>Municipal landfill leachates: A significant source for new and emerging pollutants, Science of the Total Environment 408 5147- 5157</i>	Advanced technologies for the treatment of sanitary landfill leachates have received increasing attention over the past decade. This paper presents a general review of efficient electrochemical technologies developed to decontaminate sanitary landfill leachates. An overview of the fundamental aspects of electrochemical methods, such as electrocoagulation, electro-Fenton and
10	A. Fernandes, M. J. Pacheco, L. Ciriaco and A. Lopes	2015	<i>Review on the electrochemical processes for the treatment of sanitary landfill leachates: Present and future, Applied Catalysis</i>	

a/a	Authors	Year	Title	Methodology & Results
11	Muhammad Umar, H. Abdul Aziz and M. S. Yusoff	2010	B: Environmental 176-7 183-200 <i>Variability of parameters involved in leachate pollution index and determination of LPI from four landfills in Malaysia</i> , International Journal of Chemical Engineering 1-6.	electrochemical oxidation, is provided and updated information on the application of these technologies to sanitary landfill leachates is given. The effect of the main process variables of these electrochemical technologies in the sanitary landfill leachates treatment effectiveness is discussed and a critical analysis of the prime benefits and drawbacks of its application is made. Leachate pollution index (LPI) provides an overall pollution potential of a landfill site. The parameters required to calculate LPI from a landfill site are discussed in terms of their variations over time, and their significance has been highlighted in the context of LPI. The LPI values of two semiaerobic and two anaerobic landfill sites in Malaysia have been calculated in this study. Pulau Burung Landfill Site (PBLs) was found to have the highest LPI score while Ampang Jajar Landfill Site (AJLS) showed the lowest LPI as compared to other landfills. It is concluded that LPI value can be used as a tool to assess the leachate pollution potential from landfill sites particularly at places where there is a high risk of leachate migration and pollution of groundwater. In this study, leachates from three different types of landfills, namely active uncontrolled, active controlled and closed controlled, were characterized, and their relationships with river water chemistry were examined monthly for a year. The influence of leachate on river water chemistry from each type of landfill depended on many factors, including the presence of a leachate control mechanism, leachate characteristics, precipitation, surface runoff and the applied treatment. Improper treatment practice led to high levels of some contaminants in the stream near the closed controlled landfill. Meanwhile, the active controlled landfill, which was located near the coastline, was exposed to the risk of contamination resulting from the pyrite oxidation of the surrounding area.
12	N. Yusof, A. Haraguchi, M. A. Hassan, M. R. Othman, M. Wakisaka and Y. Shiraj	2009	<i>Measuring organic carbon, nutrients and heavy metals in rivers receiving leachate from controlled and uncontrolled municipal solid waste (MSW) landfills</i> , Waste Management 2666-2680	In order to assess the heavy metal pollution and provide the base information in this region for The Twelfth Five-Year Plan, contents and fractions of four heavy metals (Cd, Cu, Pb and Zn) covering both sediments and soils were analyzed to study their contamination state. Three different indexes were applied to assess the pollution extent. The results showed this area was severely polluted by the four heavy metals, and the total concentrations exceeded the Chinese environmental quality standard for soil, grade III, especially for Cd. Moreover, Cd, rated as being in high risk, had a high mobility as its great contents of exchangeable and carbonates fractions in spite of its relative low content. Regression analysis revealed clay could well explain the regression equation for Cd, Cu and Zn while pH and sand could significantly interpret the regression equation for Pb. Moreover, there was a significant correlation between Non-residual fraction and Igeo for all the four metals. Correlation analysis showed four metals maybe had similar pollution sources.
13	Jiang M, Zeng G, Zhang C, Ma X, Chen M, et al.	2013	<i>Assessment of Heavy Metal Contamination in the Surrounding Soils and Surface Sediments in Xiawangang River, Qingshitang District</i> , PLoS ONE 8 (8): e71176	Authors here measured the concentration of Cd, Cr, Pb, Cu, and Zn in various fish tissues (muscle, gills, and liver) of 18 fish species collected from Ganga river. It is the survey regarding metal concentration in fish tissues increasing day by day. The metal concentration in different fish tissues varied on the following range. Despite lower estimated daily intake (EDI) of fish in the area (per recommended daily allowance guidelines), values of daily average consumption were lower than the recommended values by FAO/WHO/EFSA, and in fish samples these were below the provisional permissible levels for human consumption. The continuous exposure to heavy metals has been linked to the development of mental retardation, kidney damage, various cancers, and even death in instances of very high exposure in human body!
14	Pradip Kumar Maurya and D. S. Malik	2018	<i>Bioaccumulation of heavy metals in tissues of selected fish species from Ganga river, India, and risk assessment for human health</i> , Human and Ecological Risk Assessment	This study assessed water quality at several sites across Missouri (near wastewater treatment plants and airborne release sites of bisphenol A) based on hormone receptor activation potencies and chemical concentrations present in the surface water. Was hypothesized that bisphenol A and ethinylestradiol would be greater in water near permitted airborne release sites and wastewater treatment plant inputs, respectively, and that these two compounds would be responsible for the majority of activities in receptor-based assays conducted with water collected near these sites. Estrogen and androgen receptor activities of surface water samples were predictive of wastewater input, although the lower sensitivity of the ethinylestradiol ELISA relative to the very high sensitivity of the bioassay approaches did not allow a direct comparison. Wastewater-influenced sites also had elevated anti-estrogenic and anti-androgenic equivalence, while sites without wastewater discharges exhibited no antagonist activities.
15	C. D. Kassotis et al.	2015	<i>Characterization of Missouri surface waters near point sources of pollution reveals potential novel atmospheric route of exposure for bisphenol A and wastewater hormonal activity pattern</i> , Science of the Total Environment 524–525 (2015) 384–393	An extensive water sampling was carried out from stream tributaries, open channels, drainages, and seepages during the snow-melting season in 2001.
16	Krishna Woli, Toshiyuki	2002	<i>Magnitude of Nitrogen Pollution in Stream Water due</i>	

a/a	Authors	Year	Title	Methodology & Results
17	Nagumo Ryusuke Hatano	2005	<i>to Intensive Livestock Farming Practices, Soil Science and Plant Nutrition</i> 48 (6): 883-887	Total nitrogen (TN) concentration was determined and water flow was measured. About 40% of the increased N load in the main tributary in the intensive livestock farming area was occupied by a single constructed wetland confirming that the drainage from this facility acted as the point source of pollution in the area.
	Stavroula Galanopoulou, Andreas Vgenopoulos, Nikolaos Conispoliatis		<i>DDTs and other chlorinated organic pesticides and polychlorinated biphenyls pollution in the surface sediments of Keratsini harbour, Saronikos gulf, Greece, Marine Pollution Bulletin, Volume 50, Issue 5, May 2005, Pages 520-525</i>	Sediment samples were collected from Keratsini harbour, Saronikos gulf, Greece and were analysed for chlorinated organic pesticides (DDTs, HCB, Lindane) and polychlorinated biphenyls (PCBs). High total DDTs values were detected in all the sediments samples ranging from 9.1 to 75.6 µg/g, dry weight. PCBs concentrations range from 47.8 to 351.8 ng/g. The results and especially the high concentrations of DDTs reflect the influence of the industrial and urban wastes in the pollution for the Keratsini harbour environment.
	I. K. Konstantinou et al.		<i>The status of pesticide pollution in surface waters (rivers and lakes) of Greece. Part I. Review on occurrence and levels, Environmental Pollution</i> 141 (2006) 555e570	This review evaluates and summarizes the results of long-term research projects, monitoring programs and published papers concerning the pollution of surface waters (rivers and lakes) of Greece by pesticides. Pesticide classes mostly detected involve herbicides used extensively in corn, cotton and rice production, organophosphorus insecticides as well as the banned organochlorines insecticides due to their persistence in the aquatic environment. The detected concentrations of most pesticides follow a seasonal variation, with maximum values occurring during the late spring and summer period followed by a decrease during winter. However, elevated concentrations were recorded in areas of high pesticide use and intense agricultural practices. Generally, similar trends and levels of pesticides were found in Greek rivers compared to pesticide contamination in other European rivers. Monitoring of the Greek water resources for pesticide residues must continue, especially in agricultural regions, because the nationwide patterns of pesticide use are constantly changing. Moreover, emphasis should be placed on degradation products not sufficiently studied so far.
18	K. E. Murray et al.	2010	<i>Prioritizing research for trace pollutants and emerging contaminants in the freshwater environment, Environmental Pollution</i> 158 (2010) 3462e3471	In the present work authors examined literature containing occurrence and toxicity data for three broad classes of trace pollutants and ECs (industrials, pesticides, and pharmaceuticals and personal care products (PPCPs)), and assesses the relevance of 71 individual compounds. The evaluation indicates that widely used industrials (BPF) and PPCPs (AHTN, HHCB, ibuprofen, and estriol) occur frequently in samples from the freshwater environment but toxicity data were not available; thus, it is important to establish their ADI. The highest priority pollutants for regulation and treatment should include industrials (PFOA, PFOS and DEHP), pesticides (diazinon, methoxychlor, and dieldrin), and PPCPs (EE2, carbamazepine, βE2, DEET, triclosan, acetaminophen, and E1) because they occur frequently in the freshwater environment and pose a human health hazard at environmental concentrations. In this work 3 different monitoring campaigns were performed over a period of seven months. For quality assessment of river water analyses, an analytical protocol was developed employing a solid-phase extraction (SPE) method, followed by two methods based on liquid chromatography-mass spectrometry (two LC-MS systems with ion trap and time-of-flight analysers) in order to carried out the unequivocal detection and quantification of the target contaminants. The results obtained during the monitoring campaign were classified in turn into two categories: contaminants in general called 'emergents', and priority substances or candidate pollutants from domestic and industrial activities. This classification allows us to evaluate the impact of both contributions, typically domestic and industrial, on the river waters. At the same time it enables us to get a first idea about the effectiveness of the urban wastewater treatment plants (WWTPs) that release the effluents to those rivers in eliminating or removing contaminants
19	M. J. Martí'nez Bueno et al.	2010	<i>Pilot survey of chemical contaminants from industrial and human activities in river waters of Spain, Intern. J. Environ. Anal. Chem. Vol. 90, Nos. 3–6, 15 March–15 May 2010, 321–343</i>	The evaluation is based on exposure data collected between 2002 and 2013 by the Swedish pesticide monitoring program and includes 1308 individual samples, detecting mixtures of up to 53 pesticides (modal=8). Pesticide mixture risks were evaluated using three different scenarios for non-detects (best-case, worst-case and using the Kaplan-Meier method). Validated effect-based assessments and in-situ experiments might therefore be a necessary complement to chemical monitoring efforts. The fact that the five different RQs for the three different scenarios differ substantially emphasizes the paramount importance of being clear about the aims of a mixture toxicity assessment and its underlying assumptions
20	M. Gustavsson et al.	2017	<i>Pesticide mixtures in the Swedish streams: Environmental risks, contributions of individual compounds and consequences of single-substance oriented risk mitigation, Science of the Total Environment</i> 598 (2017) pp. 973–983	Hydrochemical data were mostly gathered from environmental monitoring
21	Jens Hartmann et	2014	<i>A Brief Overview of the</i>	

a/a	Authors	Year	Title	Methodology & Results
23	al. Michael Hendryx, Jamison Conley, Evan Fedorko, Juhua Luo and Matthew Armistead	2012	<i>GLOBAL River Chemistry Database, GLORICH</i> , Procedia Earth and Planetary Science 10 (2014) 23 – 27 <i>Permitted water pollution discharges and population cancer and non-cancer mortality: toxicity weights and upstream discharge effects in US rural-urban areas</i> , Hendryx <i>et al.</i> International Journal of Health Geographics 2012, 11: 9.	programs, but also from scientific literature. The data were homogenized and test routines for the feasibility of data helped to identify erroneous or implausible data. The data base is of particular interest to assess terrestrial matter inputs to head water streams, as a large number of small catchments are included. In the future, the database will be steadily extended by integrating new data (sampling locations as well as parameters like trace elements or isotopes) to provide an evolving tool for the scientific community This study conducts statistical and spatial analyses to investigate amounts and types of permitted surface water pollution discharges in relation to population mortality rates for cancer and non-cancer causes nationwide and by urban-rural setting. Data from the Environmental Protection Agency's (EPA) Discharge Monitoring Report (DMR) were used to measure the location, type, and quantity of a selected set of 38 discharge chemicals for 10,395 facilities across the contiguous US. Chemicals not currently recognized as carcinogens may nevertheless play a role in contributing to cancer mortality risk. Spatial models allow for the examination of geographic variability not captured through the regression models It was decided to conduct a preliminary survey of selected potentially toxic element (PTE) concentrations in agricultural soils and the PTEs in irrigation waters in the area to determine what potential pollution and health risk may exist. The pH and concentrations of calcium (Ca), magnesium (Mg), and heavy metals were determined in water samples from along the Nilufer River, above and below the industrialized area, and one of its tributaries, the Ayvali Canal. The results indicated considerable pollution from industry and city sewage in the surface waters, which are used directly by local farmers for irrigation of adjacent fields. Total heavy metal contents of the Fluvisols and Vertisols showed that these agricultural soils were polluted with iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), cadmium (Cd), cobalt (Co), chromium (Cr), nickel (Ni), and lead (Pb). The DTPA-extractable Cd, Cu, Fe, Mn, and Zn concentrations in irrigated Fluvisols and Vertisols indicated that the practice caused the accumulation of the Cd and Cu in the upper parts of the soil profiles. In the longer term, irrigation of the soils with the polluted waters may damage soil, crop, and human health
24	C. Aydinalp, E. A. Fitz Patrick, and M. S. Cresser	2005	<i>Heavy Metal Pollution in Some Soil and Water Resources of Bursa Province, Turkey</i> , Communications in Soil Science and Plant Analysis, 36: pp. 1691–1716, 2005	The results indicated considerable pollution from industry and city sewage in the surface waters, which are used directly by local farmers for irrigation of adjacent fields. Total heavy metal contents of the Fluvisols and Vertisols showed that these agricultural soils were polluted with iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), cadmium (Cd), cobalt (Co), chromium (Cr), nickel (Ni), and lead (Pb). The DTPA-extractable Cd, Cu, Fe, Mn, and Zn concentrations in irrigated Fluvisols and Vertisols indicated that the practice caused the accumulation of the Cd and Cu in the upper parts of the soil profiles. In the longer term, irrigation of the soils with the polluted waters may damage soil, crop, and human health
25	X. Gao et al.	2018	<i>Hydrological controls on nitrogen (ammonium versus nitrate) fluxes from river to coast in a subtropical region: Observation and modeling</i> , Journal of Environmental Management 213 (2018) 382e391	High-frequency observations and modeling of river fluxes in subtropical regions are required to understand nutrient cycling and predict water quality and ecological responses. The present study focused on the distinct characteristics of two important inorganic nitrogen forms (ammonium and nitrate). Not all nitrogen dynamics are easily synthesized by this approach, and extreme floods might produce a greater deviation in estimating nitrogen loads. These findings represent important implications for coastal ecology and provide opportunity on improving observation and modeling.
26	Anna Jurado, Enric Vázquez-Suñé, Jesus Carrera, Miren López de Alda, Estanislao Pujades, Damià Barceló	2012	<i>Emerging organic contaminants in groundwater in Spain: A review of sources, recent occurrence and fate in a European context</i> , Science of The Total Environment Volume 440, 1 December 2012, Pages 82-94	The cohort-component method used in the 2015 Revision requires a uniform age format for the estimation of the size and structure of a population and the measurement of vital events. For the purpose of global population estimates and projections, most empirical data are only available in five year age groups. As a consequence, all results produced by the cohort-component method in the 2015. Revision are also in five-year age groups and, for vital events, represent five-year periods. Groundwater is considerably less contaminated than other water bodies. There is insufficient information to assess the fate of EOCs in the aquifers. Establishment of environmental threshold value to protect groundwater quality
27	Biplob Das, Rick Nordin, Asit Mazumder	2009	<i>Watershed land use as a determinant of metal concentrations in freshwater systems</i> , Environmental Geochemistry and Health December 2009, Volume 31, Issue 6, pp 595–607	Concentrations of Fe, Mn, Cu, dissolved organic matter (DOM), and pH were synthesized from 30 publications to determine the factors regulating concentrations and behaviour of metals in freshwater. Results suggest that contrasting watershed land use can directly (erosion and runoff) and indirectly (in-lake processes including metal–DOM–pH interactions) affect the metal concentrations in freshwater systems. First, lakes, rivers, and streams with urbanized watersheds are the most susceptible to increased concentrations of metals. Secondly, these results also suggest that regardless of high or low DOM in the water column, pH would affect metal concentrations in freshwater systems. Nonetheless, free metal ions would be higher in freshwater systems with acidic water and low DOM
28	A. Schaeffer, H. Hollert, H. T. Ratte, M. Ross-Nickoll, J. Filser, M. Matthies, J.	2009	<i>An indispensable asset at risk: merits and needs of chemicals-related environmental sciences</i> , Environ. Sci. Pollut. Res. 16	Within this article, is intended to elucidate the merits and the emerging challenges of chemicals-related environmental sciences. The manuscript is supported by more than 70 professors and university academics of leading institutions in Germany, Switzerland, Austria, and other countries in Europe, but addresses topics of global concern. Many environmental problems of

a/a	Authors	Year	Title	Methodology & Results
	Oehlmann, M. Scheringer, R. Schulz, A. Seitz.		(2009) 410–413	pollutants remain to be addresses, since new chemical compounds or classes of new compounds are continuously developed and brought to the market and sooner or later "emerge" in the environment. Further issues are the inclusion of transformation products and chemical mixtures in environmental risk assessment, the long-term presence of xenobiotics bound to soils and sediments, as well as an understanding of the ecological relevance of ecotoxicological end points.
29	R. Meffe, I. de Bustamante	2014	<i>Emerging contaminants in surface water and groundwater: a first overview of the situation in Italy</i> , Sci. Total Environ. 481 (2014) 280–295	The reviewed research works have been published between 1997 and 2013. The majority of the studies have been carried out in Northern Italy and to a lower extent in Central Italy. Only a limited number of research studies report EOC concentrations in water resources of Southern Italy. The EOCs that have been more frequently studied are in the following descending order, pesticides (16), pharmaceuticals (15), industrials (13), estrogens (7) and illicit drugs (2). The present review reveals the serious contamination status of Italian surface water and groundwater especially by pesticides, industrials and to a lower extent by pharmaceuticals and the necessity to foster the research on EOC occurrence in Italian water resources, in particular in Southern Italy where a limited number of investigations currently exist the most important step in monitoring for ECs in wastewaters and in the environment is sampling. This is fundamental to obtaining representative data. To monitor treatment process performance for the removal of ECs, corresponding grab samples can be used to compensate for hydraulic retention time (HRT) there are very few studies which have monitored their performance for EC removal. Further studies of these process types are needed to determine fate and removal of ECs during treatment, considering their likely implementation into the conventional WwTW flow sheet. Environmental monitoring must also now apply a holistic approach.
30	B. Petrie, R. Barden, B. Kasprzyk-Hordern	2015	<i>A review on emerging contaminants in wastewaters and the environment: current knowledges understudied areas and recommendations for future monitoring</i> , Water Res. 71 (2015) 3–27.	This paper provides a review of the types of emerging organic groundwater contaminants (EGCs) which are beginning to be found in the UK. EGCs are compounds being found in groundwater that were previously not detectable or known to be significant and can come from agricultural, urban and rural point sources. Specific determinants frequently detected include pesticides metabolites, pharmaceuticals including carbamazepine and triclosan, nicotine, food additives and alkyl phosphates. This paper discusses the routes by which these compounds enter groundwater, their toxicity and potential risks to drinking water and the environment. It identifies challenges that need to be met to minimize risk to drinking water and ecosystems.
31	M. Stuart, D. Lapworth, E. Crane, A. Hart	2012	<i>Review of risk from potential emerging contaminants in UK groundwater</i> , Sci. Total Environ. 416 (2012) 1–21	A new method was developed to extract samples of biosolids using pressurized liquid extraction (PLE), coupled with cleanup of extracts using solid-phase extraction. Samples of biosolids and wastewater were analyzed for caffeine and CBZ and five of its metabolites. The analyses were quantified using liquid chromatography–electrospray ionization tandem mass spectrometry. A mass balance calculation showed that the majority of CBZ and its metabolites exist in the aqueous phase (i.e., wastewater), rather than in the biosolids, 78 g of CBZ and its metabolites enters the Peterborough WWTP daily, and 91 g is discharged from the WWTP daily in the combined suspended solids and aqueous phases of the wastewater. The calculated daily inputs into the WWTP are somewhat less than the inputs of 192 g estimated from Canadian annual sales data for CBZ.
32	X. Y. Miao, J. J. Yang, C. D. Metcalfe	2005	<i>Carbamazepine and its metabolites in wastewater and in biosolids in a municipal wastewater treatment plant</i> , Environ. Sci. Technol. 39 (19) (2005) 7469–7475	The chemical analysis of leachate produced by these landfill sites and corresponding river section (at five river points) has been performed for 16 selected parameter (Temperature, Odor, pH, Turbidity, Conductivity, COD, Total Solids, Sulphide, Chloride, Nitrate, Iron) in the first stage and for 8 parameters (pH, Conductivity, COD, Total Solids, Chloride, Nitrate, Iron) in second stage. The study was conducted between August to October, 2000 (rainy season). It is clear from the study that the river water quality is affected by the presence of landfill surface runoff. Its impact can be seen in the region where the drains are meeting the river. This is one of the causes of river pollution apart from other major municipal and industrial sources.
33	M. Zafar and B. J. Alappat,	2004	<i>Landfill Surface Runoff and Its Effect on Water Quality on River Yamuna</i> , JOURNAL OF ENVIRONMENTAL SCIENCE AND HEALTH Part A—Toxic/Hazardous Substances & Environmental Engineering Vol. A39, No. 2, pp. 375–384, 2004	A study of some physical and chemical analysis was carried out to determine the level of pollution in the river. Total Dissolved Solids, TDS, pH, Colour and Temperature measurements were obtained for nine locations on the 21 km river stretch. The trends of each of the 21 parameters from the urbanized stretch of the river have been observed to follow a pattern that can be categorized as similar, mirrored, somersault and composite of mirrored and somersault. More studies were recommended in this direction as well as in determining the locations of factories and industries contributing to the pollution level around
34	Fakayode, S. O.	2005	<i>Impact assessment of industrial effluent on water quality of the receiving Alaro river in Ibadan Nigeria</i> , AJEAM-RAGEE 10: 1-13.	

a/a	Authors	Year	Title	Methodology & Results
35	Kanu, Ijeoma and Achi, O. K.	2011	<i>Industrial Effluents and Their Impact on Water Quality of Receiving Rivers in Nigeria</i> , Journal of Applied Technology in Environmental Sanitation, 1 (1): 75-86	<p>Ewupe and their effluent disposal programs will need to be ascertained. With competing demands on limited water resources, awareness of the issues involved in water pollution, has led to considerable public debate about the environmental effects of industrial effluents discharged into aquatic environments. Industrial effluents are characterized by their abnormal turbidity, conductivity, chemical oxygen demand (COD), total suspended solids (TSS), biological oxygen demand (BOD), and total hardness. Waste effluents rich in decomposable organic matter, is the primary cause of organic pollution. Waste waters from textile, brewery, food and beverages, paper, pulp and palm oil industries, the cases chosen, are believed to give a broad outline of industrial wastes as well as disposal problems.</p> <p>Policy-makers and scientists will have to cooperate to create an initial groundwater emerging pollutant priority list, to answer at consumer demands for safety and to the lack of conceptual models for emerging pollutants in groundwater. This paper starts from the current regulatory framework and from the literature overview to explain how the missing conceptual model for OWCs could be developed. In the present paper the attention was focused on the case of OWCs using simplified pathways: from households to WWTPs to rivers and to groundwater; from bio solids, greywater, and livestock manure to soils and groundwater.</p> <p>The river under study was divided into three regions for sample collection. The collected samples were transported back to the laboratory the samples were kept in an ice cooler and upon arrival they were refrigerated at 4 °C and analysed within 1 wk. Except for nitrate determination that was carried out using phenoldisulphonic acid spectrophotometric method (Michael 1950), APHA-AWWA-WPCF method (1981) was used for all the parameters studied on water samples. The IITA (1979) method was used for determination of heavy metals in sediment samples. In all the parameter levels, the values at US2 were found to be higher than US1. This may be due to the back flow movement observed between US2 and POD during leachate intrusion. The contributions of heavy metals to the surface water by the leachate appeared to be slight. However, according to this work higher values of Lead and Zinc were observed at US1. The source of this may be from vehicular emission along the course of the river in the upstream region.</p>
36	Lucrezia Lamastra, Matteo Balderacchi, Marco Trevisan	2016	<i>Inclusion of emerging organic contaminants in groundwater monitoring plans</i> , MethodsX Volume 3, 2016, Pages 459-476	<p>Four sampling stations were established, with sampling station 1 (control) upstream before effluent discharged points from the industrial layout. Cadmium (Cd) Manganese (Mn), Chromium (Cr) and Cobalt (Co) concentrations were analysed using Shimadzu atomic absorption spectrophotometer (model AA-6800, Japan) after wet digestion. Surface water temperatures were found to be above WHO standards for domestic water supply. Use of the water under study for domestic and which depicts polluted water. agricultural purposes thus poses serious toxicological risk.</p>
37	Nubi, O. A. I Osibanjo, O. Nubi, A. T.	2008	<i>Impact assessment of dumpsite leachate on the qualities of surface water and sediment of river Eku, Ona-Ara local government, Oyo State, Nigeria</i> . Science World Journal 3 (3): 17-20	<p>In this study the significant positive correlation observed between lead and chromium, lead and nickel, and between chromium and nickel indicates that as the concentration of lead in onions bulbs increases the concentrations of chromium and nickel also increases suggesting that same source is responsible for the presence of these metals at the concentrations determined. Use of the water under study for domestic and agricultural purposes thus poses serious toxicological risk.</p>
38	Udiba U. U., Gauje Balli, Ashade N. O., Ade-Ajayi F. A., Okezie V. C., Aji B. M. and Agboun T. D. T.	2014	<i>An assessment of the heavy metal status of River Galma around Dakace industrial layout, Zaria, Nigeria</i> , Merit Research Journal of Environmental Science and Toxicology (ISSN: 2350-2266) Vol. 2 (8) pp. 176-184, November, 2014	<p>The global NEWS model was calibrated and then used to quantify the long term trend of dissolved inorganic nitrogen (DIN) export from two tributaries of Jiulong River (SE China). Scenario analysis and source tracking suggest that reductions of anthropogenic N inputs of at least 30% in the North River (emphasis on fertilizer and manure) and 50% in the West River (emphasis on fertilizer) could significantly improve water quality and mitigate eutrophication in both river and coastal waters.</p>
39	Udiba U. U., Anyanwu Stella, Gauje Balli, Dawaki S. I., Oddy-Obi I. C., Agboun T. D. T.	2015	<i>Toxicity Potential of Allium cepa L. as a Bioindicator of Heavy Metal Pollution Status of River Galma Basin Around Dakace Industrial Layout, Zaria, Nigeria</i> , International Journal of Biological Sciences and Applications 2015; 2 (6): 76-85	<p>In this study Human Risk Assessment (HRA) was conducted by comparing the measured concentrations with drinking water thresholds from guidelines or calculated in this study; first considering the exposure to each single EC and then the entire mixture. Thirteen ECs were measured. The results of the HRA excluded any risks for consumers in each scenario considered. This is one of the most comprehensive studies assessing the presence of a large number of ECs in the whole drinking water network of a city, and the risks for human health.</p>
40	D. Yu et al.	2015	<i>Modeling increased riverine nitrogen export: Source tracking and integrated watershed-coast management</i> , Marine Pollution Bulletin 101 (2015) 642–652	<p>Source and treated drinking water samples from 29 drinking water treatment</p>
41	F. Riva et al.	2018	<i>Monitoring emerging contaminants in the drinking water of Milan and assessment of the human risk</i> , International Journal of Hygiene and Environmental Health 221 (2018) 451–457	
42	S. T. Glassmeyer	2017	<i>Nationwide reconnaissance of</i>	

a/a	Authors	Year	Title	Methodology & Results
43	et al. Christina I. Nannou, Christina I. Kosma and Triantafyllos A. Albanis	2014	<i>contaminants of emerging concern in source and treated drinking waters of the United States</i> , Science of the Total Environment 581-582 (2017) pp. 909–922 <i>Occurrence of pharmaceuticals in surface waters: analytical method development and environmental risk assessment</i> , International Journal of Environmental Analytical Chemistry, 14th Symposium on Chemistry and Fate of Modern Pesticides, Ioannina, Greece (18–21 September 2014).	plants (DWTPs) were analysed as part of a two-phase study to determine whether chemical and microbial constituents, many of which are considered contaminants of emerging concern, were detectable in the waters. The data collected as part of this project will be used to help inform evaluation of unregulated contaminants in surface water, groundwater, and drinking water. The method developed in this study was applied for the analysis of pharmaceutical residues in surface waters from different sampling points along the aquatic systems of Lake Pamvotis and the River Kalamas, close to the city of Ioannina (Epirus, Greece), while the monitoring programme was carried out during the four seasons of the year. The results denoted a possible threat for the aquatic environment, rendering in this way the RQ method as a helpful tool for a first approach. Extensive study is needed for triclosan, salicylic acid, sulfamethoxazole and erythromycin in order to better correlate their occurrence and potential toxic effects in aquatic life and humans.
44	J. Robles-Molina, F. J. Lara-Ortega, B. Gilbert-López, J. F. García-Reyes and A. Molina-Díaz, J. Chromatogr	2014	<i>Multi-residue method for the determination of over 400 priority and emerging pollutants in water and wastewater by solid-phase extraction and liquid chromatography-time-of-flight mass spectrometry</i> , Journal of Chromatography A Volume 1350, 11 July 2014, Pages 30-43 A 1350, 30 (2014).	This article describes the development and validation of a liquid chromatography high-resolution mass spectrometry method for the simultaneous determination of over 400 multi-class priority and emerging pollutants with different physicochemical properties in environmental waters (surface water and wastewater). The proposed approach is based on the use of a database consisting of retention time/exact mass (of selected ions) pairs implemented with specific software for data analysis. The overall method performance was satisfactory with limits of quantification lower than 10ngL (-1) for the 44% of studied compounds. Recoveries between 50% and 130% were obtained for the 65% of the analytes. This developed method was applied for the determination of target analytes in real surface water and wastewater samples.

1.3. Related Work for Soil Pollution

The majority of the methods referred in the present study, as is presented in Table 3, investigate the pollution from use of agricultural fertilizers and organic pollutants, [82, 86, 87], heavy metals (HMs) [83, 85, 88, 91-94].

Table 3. Literature review of methods related to soil pollution.

a/a	Authors	Year	Title	Methodology & Results
1	Finkelman, R. B.	2019	<i>The influence of clays on human health: A medical geology perspective</i> . Clays and Clay Minerals, 67 (1), 1-6.	Humanoids have been ingesting clay for at least two million years to ease indigestion and counteract poisons. Some additional benefits may accrue from eating clays such as providing some nutrients but these benefits are far outweighed by the likely negative consequences such as tissue abrasion, intestinal blockage, anemia, exposure to pathogens and toxic trace elements, and potassium overdose. Inhalation of airborne minerals including clays has impacted the health of millions. In South Africa, clay-poor soils yield crops lacking in essential nutrients and may be the principal cause of Msileni joint disease. Clearly, a detailed knowledge of the clays in the environment can have significant benefits to human health and wellbeing.
2	Cupit M, Larsson O, de Meert C, Eduljee GH, Hutton MC.	2002	<i>Assessment and management of risks arising from exposure to cadmium in fertilisers - I</i> , The Science of the Total Environment 291 (2002) 167–187	A risk assessment protocol has been developed for use by individual EU Member States with appropriate selection of input data, to assess the risks to humans and the environment arising from exposure to cadmium in fertilisers. The protocol comprises of three modules: 1. the accumulation module. 2. the exposure module. 3. The risk characterisation module. Particular risk groups can be characterised, namely of: children; smokers; women with low iron stores; consumers of food items with high cadmium content; and extreme consumers of staple food items. At present, with the data available, it is not possible to characterise risk groups in detail, either at EU level or at Member State level. However, most Member States appear to have an average intake of cadmium which is lower than the WHO's PTWI
3	Zhongmin Jial, Siyue Li & Li Wang	2018	<i>Assessment of soil heavy metals for eco-environment and human health in a rapidly urbanization area of the upper Yangtze Basin</i> , SCIE nTifC Reports (2018) 8: 3256 DOI: 10.1038/s41598-018-21569-6	Averages of HMs were far below grade II threshold level of the Chinese Environmental Quality standards for soils, whereas Cd, As and Hg considerably exceeded the local background values. EF suggested overall moderate enrichments of Cd and Se, resulting in soils uncontaminated to moderately contaminated with them. There were no significant carcinogenic and non – carcinogenic risks for adults, children however showed significant non – carcinogenic effect. Our first assessment provided important

a/a	Authors	Year	Title	Methodology & Results
4	Olivier Núñez et al.	2017	<i>Association between heavy metal and metalloid levels in topsoil and cancer mortality in Spain</i> , Environ Sci Pollut Res (2017) 24: 7413–7421.	information for policy making to reduce the potential effects of soil contamination on human and eco-environment The aim of this study was to assess the possible association between heavy metal and metalloid levels in topsoil (upper soil horizon) and cancer mortality in mainland Spain. The elements included were determined by ICP-MS at 13,317 sampling points. To estimate the effect of heavy metal levels in topsoil composition on mortality, we fitted Besag, York and Mollié models, which included each town's factor scores as the explanatory variable. Integrated Nested Laplace The results showed an association between trace contents of heavy metals and metalloids in topsoil and mortality due to tumors of the digestive system in mainland Spain. The results support the interest of inclusion of heavy metal levels in topsoil as a hypothesis in analytical epidemiological studies using biological markers of exposure to heavy metals and metalloids. In order to assess the heavy metal pollution and provide the base information in this region for The Twelfth Five-Year Plan, contents and fractions of four heavy metals (Cd, Cu, Pb and Zn) covering both sediments and soils were analyzed to study their contamination state. Three different indexes were applied to assess the pollution extent. The results showed this area was severely polluted by the four heavy metals, and the total concentrations exceeded the Chinese environmental quality standard for soil, grade III, especially for Cd. Moreover, Cd, rated as being in high risk, had a high mobility as its great contents of exchangeable and carbonates fractions in spite of its relative low content. There was a significant correlation between Non-residual fraction and Igeo for all the four metals. Correlation analysis showed four metals maybe had similar pollution sources.
5	Jiang M, Zeng G., Zhang C., Ma X., Chen M., et al.	2013	<i>Assessment of Heavy Metal Contamination in the Surrounding Soils and Surface Sediments in Xiawangang River, Qingshuitang District</i> , PLoS ONE 8 (8): e71176.	This study was conducted to find out the present level of trace metals, their sources and the relationships among them in selected land uses. A Dry Zone soil catena consisting of uncultivated, paddy-cultivated and vegetablecultivated land uses was selected for this study. A total of 58 soil samples were collected on the basis of latin hypercube sampling approach. Soil samples were analyzed for the total concentrations of Cd, Cu, Pb, Ni and Zn. The PCA confirmed the contribution of anthropogenic factors on Cd levels observed in this Dry Zone soil catena. The PCA indicated that Cu, Zn and Pb would have originated from the mixed factor of natural and anthropogenic sources.
6	Rosemary et al.	2014	<i>Concentrations of Trace Metals in Selected Land Uses of a Dry Zone Soil Catena of Sri Lanka</i> , Tropical Agricultural Research Vol. 25 (4): 512 – 522 (2014)	Choosing a different season for OMW application than the commonly practiced winter, may help avoid negative effects. However, understanding of the OMW-soil interaction during different seasons is still incomplete due to the lack of comparative data. The risks of groundwater contamination and persistent negative effects decrease with increasing time under conditions favoring biological activity. Therefore, OMW application in spring if improved by a careful irrigation is considered as the most suitable under semiarid conditions for clay loam soils.
7	Nisreen Tamimi, Dörte Diehl, Mohand Njoum, Amer Marci, Gabriele E. Schaumann	2016	<i>Effects of olive mill wastewater disposal on soil: Interaction mechanisms during different seasons</i> , J. Hydrol. Hydromech., 64, 2016, 2, 176–195	The concentrations were mapped using regression-kriging (RK) and accuracy of predictions evaluated using the leave-one-out cross validation method. A large number of auxiliary raster maps (topographic indexes, land cover, geology, vegetation indexes, night lights images and earth quake magnitudes) were used to improve the predictions. Automation of the geostatistical mapping and use of auxiliary spatial layers opens a possibility to develop mapping systems that can automatically update outputs by including new field observations and higher quality auxiliary maps. This approach also demonstrates the benefits of organizing standardized joint European monitoring projects, in comparison to the merging of several national monitoring projects.
8	L. R. Lado et al.	2008	<i>Heavy metals in European soils: A geostatistical analysis of the FOREGS Geochemical database</i> , Geoderma 148 (2008) 189–199	Quality of soil resources as defined by their potential impact on human health by propagation of harmful elements through the food chain has been poorly studied in Europe due to the lack of data of adequate detail and reliability. The European Union's first harmonized topsoil sampling and coherent analytical procedure produced trace element measurements from approximately 22,000 locations. This unique collection of information enables a reliable overview of the concentration of heavy metals, also referred to as metal (loid) s including As, Cd, Cr, Cu, Hg, Pb, Zn, Sb, Co, and Ni. In this article has been proposed that in some cases (e.g. Hg and Cd) the high concentrations of soil heavy metal attributed to human activity can be detected at a regional level. While the immense majority of European agricultural land can be considered adequately safe for food production, an estimated 6.24% or 137,000km needs
9	G. Tóth et al.	2016	<i>Heavy metals in agricultural soils of the European Union with implications for food safety</i> , Environment International 88 (2016) 299–309	

a/a	Authors	Year	Title	Methodology & Results
10	P. Saikkonen	2015	<i>Production and Polluted Soil in Urban Planning: The Case of Helsinki</i> , Journal of Environmental Policy & Planning, 2015 Vol. 17, No. 5, 538–552	local assessment and eventual remediation action. Polluted soil as an environmental problem is examined in cases from three different decades in Helsinki. The research material comprises official and public documents, such as planning documents, records of the City Board and interviews with the city's authorities. The analysis focuses on changes in problem classification, knowledge production, risk management and the dynamics between these. Risk management and knowledge production are argued to have been conducted in a way that masks environmental problems, their historical roots and their causes from citizens and decision-makers. Furthermore, the risk management strategy transformed ecological risks into financial risks.
11	Alamdar et al.	2014	<i>Organochlorine pesticides in surface soils from obsolete pesticide dumping ground in Hyderabad City, Pakistan: Contamination levels and their potential for air–soil exchange</i> , Science of the Total Environment 470–471 (2014) 733–741	This study was conducted to examine organochlorine pesticides (OCPs) contamination levels in the surface soil and air samples together with air–soil exchange fluxes at an obsolete pesticide dumping ground and the associated areas from Hyderabad City, Pakistan. Elevated concentrations of DDTs and HCHs at pesticide dumping ground and its surroundings pose potential exposure risk to biological organisms, to the safety of agricultural products and to the human health. The study thus emphasizes the need of spatio-temporal monitoring of OCPs at local and regional scale to assess and remediate the future adverse implications.
12	G. Shi et al.	2008	<i>Potentially toxic metal contamination of urban soils and roadside dust in Shanghai, China</i> , Environmental Pollution 156 (2008) 251–260	A detailed investigation was conducted to understand the contamination characteristics of a selected set of potentially toxic metals in Shanghai. The amount of Pb, Zn, Cu, Cr, Cd and Ni were determined from 273 soil/dust samples collected within urban area. The results indicated that concentration of all metals except Ni in soils was significant, and metal pollution was even severer in roadside dust.
13	Viacheslav Vasenev, Yakov Kuzyakov	2018	<i>Urban soils as hot spots of anthropogenic carbon accumulation: Review of stocks, mechanisms and driving factors</i> , Land Degrad. Dev. 2018; 29: 1607–1622	Data on soil organic carbon (SOC), soil inorganic carbon (SIC), black (pyrogenic) carbon (BC), and nitrogen contents and stocks in urban soils were collected from 100 peer - reviewed papers. Long - term C input from outside the cities and associated C accumulation coincided with upward soil growth of ~50 cm per century, and continuous accumulation of 15–30 kg C/m ² per century in urban soils and cultural layers. Consequently, despite the relatively small area of cities, urban soils are hot spots of long - term soil C sequestration worldwide, and the importance of urban soils will increase in future with global urbanization
14	Peter W. Abrahams	2006	<i>Soil, geography and human disease: a critical review of the importance of medical cartography</i> , Progress in Physical Geography 30, 4 (2006) pp. 490–512	Soils have a profound impact on the causation and geographical distribution of human disease and well-being. Using examples, particularly the problems of soil-transmitted helminth infections, and iodine and selenium deficiency diseases, this paper shows how maps have been used to identify problem areas, stimulate the development of aetiological hypotheses, help in the planning and management of public health problems, and assess the impact of any beneficial strategies.
15	E. C. Brevik and T. J. Sauer	2015	<i>The past, present, and future of soils and human health studies</i> , SOIL, 1, 35–46, 2015, www.soil-journal.net/1/35/2015	According to the present paper, complex interdisciplinary research teams are needed with expertise in relevant areas and the ability for team members to communicate effectively with one another at a professional level. Evidence indicates that understanding the links between soils and human health should be given more importance in human health research than it currently receives.

1.4. Related Work for Health Effects and Risks of Human Exposure to Pollutants

The majority of the articles referred to short or long term cohort studies [103, 149]. Others investigate the relation between exposure to pollutants (HMs, ECs, pesticides, insecticides, air pollutants) and elevated rate of chronic diseases such as cardiovascular, different types of cancers,

diabetes, neurodegenerative disorders like Parkinson, Alzheimer, and amyotrophic lateral sclerosis (ALS), birth defects, and reproductive disorders [96-100, 104, 105, 106, 108-112, 114, 116]. Finally, there are studies involving material and methods, clinical symptoms, physical examination signs, hematological and clinical chemistry parameters [101, 102, 105, 113, 115] as is presented in Table 4.

Table 4. Literature review of methods related health risks approximations due to pollution.

a/a	Authors	Year	Title	Methodology & Results
1	A. Moretto, C. Colosio	2013	<i>The role of pesticide exposure in the genesis of Parkinson's disease: Epidemiological studies and experimental data</i> , Toxicology 307 (2013)	The aim of this study was to address the uncertainties provided by epidemiological studies on the role of pesticide exposures in the development of PD, with the help of experimental toxicological data. Animal models that reproduce all clinical and pathological features of human PD are not available. In addition, the fundamental questions relate to the extrapolation from experimental to actual human exposure, taking also into account the role of genetic factors. A possible role of acute poisonings or

a/a	Authors	Year	Title	Methodology & Results
			24– 34	episodes of excessive exposure, and/or of combined exposures especially at early age and/or in the presence of certain genetic variants can be hypothesised. According to the available data, from a public health point of view, prevention of "high" exposures, even asymptomatic ones, especially in utero and during early age is a priority.
2	A. Gebrekidan et al.	2013	<i>Toxicological assessment of heavy metals accumulated in vegetables and fruits grown in Ginfel river near Sheba Tannery, Tigray, Northern Ethiopia, Ecotoxicology and Environmental Safety</i> 95 (2013) 171–178	According to this work the accumulation of heavy metals in vegetables resulting from irrigation with water with industrial effluents may create a potential public health risk. The authors quantified the concentration of heavy metals (Cu, Zn, Fe, Mn, Cr, Cd, Ni, Co and Pb) in soil, vegetables and the water used for irrigation at two sites (Laelay Wukro and Tahtay Wukro) around Wukro Town, Tigray, Northern Ethiopia. The concentrations of heavy metals in irrigation water measured during this study were lower than permissible limits of heavy metals allowed for irrigation water. The results indicate that Fe, Pb and Cd have high transfer factor values (mean values: 42.89, 0.84 and 0.37, respectively). The transfer pattern for heavy metals in different vegetables showed a trend in the order: Fe>Pb>Cd>Mn>Cu>Zn>Ni>Zn>Cr=Co. The heavy metal contamination of vegetables grown in Tahtay Wukro, located downstream of the tannery, may pose increased health risks in the future to the local population through consumption of vegetables.
3	M. T. Baltazar et al.	2014	<i>Pesticides exposure as etiological factors of Parkinson's disease and other neurodegenerative diseases—A mechanistic approach, Toxicology Letters</i> 230 (2014) 85–103	The role of pesticide exposure in neuro-degenerative disease has long been suspected, but the specific causative agents and the mechanisms underlying are not fully understood. For the main neurodegenerative diseases such as Parkinson's disease, Alzheimer's disease and amyotrophic lateral sclerosis there are evidences linking their etiology with long-term/low-dose exposure to pesticides such as paraquat, maneb, dieldrin, pyrethroids and organophosphates. This review aims to clarify the role of pesticides as environmental risk factors in genesis of idiopathic PD and other neurological syndromes. For this purpose, the most relevant epidemiological and experimental data is highlighted in order to discuss the molecular mechanisms involved in neurodegeneration.
4	Sharon K. Sagiv et al.	2018	<i>Prenatal Organophosphate Pesticide Exposure and Traits Related to Autism Spectrum Disorders in a Population Living in Proximity to Agriculture, Environmental Health Perspectives</i> 047012, 2018	OP exposure during pregnancy with measurements of dialkyl phosphates (DAP) metabolites in urine, and residential proximity to OP use during pregnancy using California's Pesticide Use Reporting (PUR) data and estimated associations with ASD-related traits using linear regression models. We measured traits reported by parents and teachers as well as the child's performance on tests that evaluate the ability to use facial expressions to recognize the mental state of others at 7, 10½, and 14 years of age. Prenatal DAPs were associated with poorer parent and teacher reported social behavior [e.g., a 10-fold DAP increase was associated with a 2.7-point increase (95% confidence interval (CI): 0.9, 4.5) in parent-reported Social Responsiveness Scale, Version 2, T-scores at age 14]. We did not find clear evidence of associations between residential proximity to OP use during pregnancy and ASD-related traits.
5	A. Dabass et al.	2018	<i>Systemic inflammatory markers associated with cardiovascular disease and acute and chronic exposure to fine particulate matter air pollution (PM2.5) among US NHANES adults with metabolic syndrome, Environmental Research</i> 161 (2018) 485–491	A cross sectional analysis of adult National Health and Nutrition Examination Survey (NHANES) participants (2000-2008) was carried out with linkage of CDC WONDER meteorological data and downscaler modeled USEPA air pollution data for census tracts in the continental United States. Participants were non-pregnant NHANES adults (2000-2008) with complete data for evaluating presence of metabolic syndrome and laboratory data on WBC and CRP. Exposures studied included short (lags 0-3 days and their averages), long-term (30 and 60 day moving and annual averages) PM2.5 exposure levels at the census tract level in the continental United States. There were no significant associations for WBC count. In this first national study of the effect of PM2.5 air pollution on levels of cardiovascular-disease related inflammatory markers in adults with metabolic syndrome, CRP levels were found to be significantly increased in those with this condition with increased fine particulate matter levels at lag day 0. With one third of US adults with metabolic syndrome, the health impact of PM2.5 in this sensitive population may be significant.
6	C. R. García-García et al.	2016	<i>Occupational pesticide exposure and adverse health effects at the clinical, hematological and biochemical level, Life Sciences</i> 145 (2016) 274–283	Clinical symptoms, physical examination signs, hematological and clinical chemistry parameters were measured in 189 intensive agriculture workers and 91 healthy control subjects from Almeria coastline (Southeastern Spain) to evaluate potential effects of pesticide exposure. These findings suggest that chronic occupational exposure to pesticides of lower toxicity than former compounds under integrated production systems elicit mild toxic effects, particularly targeting the skin and eyes, as well as subtle subclinical (biochemical) changes of unknown long-term consequences.
7	L. S. Engel et al.	2017	<i>Insecticide Use and Breast Cancer Risk among Farmers' Wives in the Agricultural Health Study, Environ Health Perspect.</i> 2017 Sep; 125 (9): 097002.	Farmers and their wives provided information on insecticide use, demographics, and reproductive history at enrolment in 1993-1997 and in 5-y follow-up interviews. Cancer incidence was determined via cancer registries. Among 30,594 wives with no history of breast cancer before enrolment, we examined breast cancer risk in relation to the women's and their husbands' insecticide use using Cox proportional hazards regression to estimate adjusted hazard ratios (HRs) and 95% confidence intervals (CIs). Although ever use of insecticides overall was not associated with breast cancer risk, risk was elevated among women who had ever used the organophosphates chlorpyrifos [HR=1.4 (95% CI:

a/a	Authors	Year	Title	Methodology & Results
8	Louis et al.	2017	<i>A prospective study of cancer risk among Agricultural Health Study farm spouses associated with personal use of organochlorine insecticides</i> , Environmental Health (2017) 16: 95	1.0, 2.0)] or terbufos [HR=1.5 (95% CI: 1.0, 2.1)], with nonsignificantly increased risks for coumaphos [HR=1.5 (95% CI: 0.9, 2.5)] and heptachlor [HR=1.5 (95% CI: 0.7, 2.9)]. Risk in relation to the wives' use was associated primarily with premenopausal breast cancer. We found little evidence of differential risk by tumor estrogen receptor status. Among women who did not apply pesticides, the husband's use of fonofos was associated with elevated risk, although no exposure-response trend was observed. At enrolment (1993–1997), spouses of private applicators in the cohort provided information about their own use of pesticides, including seven OCs (aldrin, chlordane, dieldrin, DDT, heptachlor, lindane, and toxaphene), and information on potential confounders. We used Poisson regression to estimate relative risks (RRs) and 95% confidence intervals (CIs) for cancers (n ≥ 3 exposed cases) reported to state cancer registries from enrolment through 2012 (North Carolina) and 2013 (Iowa), and use of the individual OCs, as well as use of any of the specific OCs. Among 28,909 female spouses, 2191 (7.58%) reported ever use of at least one OC, of whom 287 were diagnosed with cancer. Most cancers were not associated with OC use. Risk of glioma was increased among users of at least one OC (Nexposed = 11, RR = 3.52, 95% CI 1.72–7.21) and specifically among lindane users (Nexposed = 3, RR = 4.45, 95% CI 1.36–14.55). Multiple myeloma was associated with chlordane (Nexposed = 6, RR = 2.71, 95% CI 1.12–6.55). Based on 3 exposed cases each, there were also positive associations between pancreatic cancer and lindane, and ER-PR- breast cancer and dieldrin.. This article critically reviewed evidences up to date studying the associations between non-occupational pesticide exposures and respiratory health in general populations. This article also highlighted questions arising from these studies, including our recent analyses using the data from the Canadian Health Measures Survey (CHMS), for future research. We found few studies have addressed the impact of environmental pesticide exposures on respiratory health, especially on lung function, in general populations. Research findings from current studies of non-occupational pesticide exposures and their health impact in general population will help to improve the role of regulatory policies in mitigating pesticide-related public health problems, and thereafter providing greater benefit to the general population.
9	Ming Ye, Jeremy Beach, Jonathan W. Martin, Ambikaipakan Senthilselvan X,	2017	<i>Pesticide exposures and respiratory health in general populations</i> , Journal of Environmental Sciences 51 (2017) 361–370	
10	C. Piccoli et al.	2016	<i>Pesticide exposure and thyroid function in an agricultural population in Brazil</i> , Environmental Research 151 (2016) 389–398	A cross-sectional study was conducted with a random sample of 275 male and female farm residents in Farroupilha, South of Brazil. Information on sociodemographics, lifestyle and agricultural work was obtained through questionnaire. Blood samples were collected on all participants and analyzed for cholinesterase activity, serum residues of OC pesticides, and levels of free T4 (FT4), total T3 (TT3) and TSH. Non-persistent pesticides exposure assessment was based on questionnaire information on current use of pesticides, and frequency and duration of use, among others. Associations were explored using multivariate linear regression models. Subjects with detected serum concentrations of β-hexachlorocyclohexane, endrin, dieldrin, heptachlor epoxide B, γ-chlordane, transnonachlor, heptachlor, p, p'-dichlorodiphenylethane and endosulfan II experienced slight changes in TT3; however, associations were weak and inconsistent. These findings suggest that both cumulative and recent occupational exposure to agricultural pesticides may affect the thyroid function causing hypothyroid-like effects, particularly in men. AHS participants reported pesticide exposure via self-administered questionnaires at enrollment (1993–1997). ESRD cases were identified via linkage to the United States Renal Data System. Associations between ESRD and pesticide exposures were estimated with Cox proportional hazard regression models controlling for age at enrollment. Models of associations with farming and household factors were additionally adjusted for personal use of pesticides. There were identified 98 ESRD cases diagnosed between enrollment and 31 December 2011. Although women who ever applied pesticides (56% of cohort) were less likely than those who did not apply to develop ESRD (Hazard Ratio (HR): 0.42; 95% CI: 0.28, 0.64), among women who did apply pesticides, the rate of ESRD was significantly elevated among those who reported the highest (vs. lowest) cumulative general pesticide use (HR: 4.22; 95% CI: 1.26, 14.20). Among wives who never applied pesticides, ESRD was associated with husbands' ever use of paraquat (HR=1.99; 95% CI: 1.14, 3.47) and butylate (HR=1.71; 95% CI: 1.00, 2.95), with a positive exposure-response pattern for husband's cumulative use of these pesticides. This study explored the allelic frequency, linkage disequilibrium and haplotype analysis of ten common polymorphic variants of seven key genes involved in organophosphate metabolism in a children population living near an intensive agriculture area in Spain. It was hypothesized that individuals with unfavorable combinations of gene variants will be more susceptible to adverse effects from organophosphate exposure. Genomic DNA from 496 healthy children was isolated and amplified by PCR. Hydrolysis probes were used for the detection of eight specific SNPs and two copy number variants (CNVs) by using TaqMan® Assay-based real-time PCR. The adverse genotype combination potentially conferring a greater genetic risk from exposure to organophosphates was observed in 0.2% of our study population. This information allows broadening our knowledge about
11	J. F. Lebov et al.	2015	<i>Pesticide exposure and end-stage renal disease risk among wives of pesticide applicators in the Agricultural Health Study</i> , Environmental Research 143 (2015) 198–210	
12	A. Gómez-Martin et al.	2015	<i>Polymorphisms of pesticide-metabolizing genes in children living in intensive farming communities</i> , Chemosphere 139 (2015) 534–540	

a/a	Authors	Year	Title	Methodology & Results
13	X Rupali Das, Andrea Steege, Sherry Baron, John Beckman & Robert Harrison	2001	<i>Pesticide-related Illness among Migrant Farm Workers in the United States</i> , Journal of Occupational and Environmental Health, 7: 4, 303-312	<p>differential susceptibility toward environmental toxicants and may be helpful for further research to understand the inter-individual toxicokinetic variability in response to organophosphate pesticides exposure.</p> <p>A few categories (organophosphates and carbamates, inorganic compounds, and pyrethroids) account for over half of the cases of acute illness. Skin effects dominate the illnesses, although ocular and systemic effects are also common. Exposures occur in various ways (e.g., residues, drift), suggesting that the use of pesticides creates a hazardous work environment for all farm workers. The health care system provided through the Migrant Health Program appears to be underutilized, partially due to barriers to health care access. Current surveillance effort should be supported. Risk prevention should focus on substitution of safer compounds, establishing effective protections, and ensuring that these measures are enforced. Improved education for health care providers should be a priority. Growers should be educated about alternative forms of pest control and incentives should be provided to encourage their use.</p> <p>According to existed literature there is a huge body of evidence on the relation between exposure to pesticides and elevated rate of chronic diseases such as different types of cancers, diabetes, neurodegenerative disorders like Parkinson, Alzheimer, and amyotrophic lateral sclerosis (ALS), birth defects, and reproductive disorders. There is also circumstantial evidence on the association of exposure to pesticides with some other chronic diseases like respiratory problems, particularly asthma and chronic obstructive pulmonary disease (COPD), cardiovascular disease such as atherosclerosis and coronary artery disease, chronic nephropathies, autoimmune diseases like systemic lupus erythematosus and rheumatoid arthritis, chronic fatigue syndrome, and aging. Authors in this review, present the highlighted evidence on the association of pesticide's exposure with the incidence of chronic diseases and introduce genetic damages, epigenetic modifications, endocrine disruption, mitochondrial dysfunction, oxidative stress, endoplasmic reticulum stress and unfolded protein response (UPR), impairment of ubiquitin proteasome system, and defective autophagy as the effective mechanisms of action.</p>
14	S. Mostafalou, M. Abdollahi	2013	<i>Pesticides and human chronic diseases: Evidences, mechanisms, and perspectives</i> , Toxicology and Applied Pharmacology 268 (2013) 157–177	<p>In this study the separate analysis of roof runoff indicated that these can contribute significant concentrations of FS, phosphorus (P) and potentially toxic elements such as zinc (Zn), and suggests a level of 'background' contamination originating from wash-off of bird droppings and in the case of Zn galvanised surfaces. On average hardstanding runoff showed enhanced concentrations of >4 orders of magnitude for FC and 2-3 for major nutrients and carbon relative to roof runoff. Where situations allowed, a comparison of water upstream and downstream of the farmyard demonstrated they acted as a source of multiple contaminants not only during hydrologically active storm events but also during dry periods. Contamination pathways included a combination of both point (e.g., septic overflows) and non-point (e.g., seepage from livestock housing) sources. Farmyards situated within intensive livestock farming areas such as SW Scotland, would be expected to have significant local and accumulated downstream impacts on the aquatic environment. Localised impacts would be particularly important for headwaters and low order streams</p>
15	A. C. Edwards et al.	2008	<i>Farmyards, an overlooked source for highly contaminated runoff</i> , Journal of Environmental Management 87 (2008) 551–559	<p>This study looks at all airports of Texas, and 2134 incidences of childhood leukemia (children age 9 and under) state-wide over a 10-year period. The distance to airports of block groups with standardized incidence ratios >100 for childhood leukemia was found to be shorter than the distance to airports for block groups with standardized incidence ratios <100, to a 98% level of confidence. A Poisson regression model was developed to estimate incidences of childhood leukemia, based on county-wide benzene emissions. Benzene emissions from airports were found to be a statistically significant predictor variable. The two analyses provide evidence of an association between airports and incidences of childhood leukemia in Texas</p>
16	Senkayi et al.	2014	<i>Investigation of an association between childhood leukemia incidences and airports in Texas</i> , Atmospheric Pollution Research (APR) 5 (2014), 189-195	<p>Clinical symptoms, physical examination signs, hematological and clinical chemistry parameters were measured in 189 intensive agriculture workers and 91 healthy control subjects from Almeria coastline (Southeastern Spain) to evaluate potential effects of pesticide exposure. According to the present study chronic occupational exposure to pesticides of lower toxicity than former compounds under integrated production systems elicit mild toxic effects, particularly targeting the skin and eyes, as well as subtle subclinical (biochemical) changes of unknown long-term consequences</p>
17	C. R. García-García et al.	2016	<i>Occupational pesticide exposure and adverse health effects at the clinical, hematological and biochemical level</i> , Life Sciences 145 (2016) 274–283	<p>Conducted a study of women enrolled in the Western New York Exposures and Breast Cancer (WEB) Study. Methylation of nine genes, was assessed using bisulfite-based pyrosequencing. TSP exposure at each woman's home address at birth, menarche, and when she had her first child was estimated. TE exposure was modeled for each woman's residence at menarche, her first birth, and twenty and ten years prior to diagnosis. Unconditional logistic regression was employed to estimate odds ratios (OR) of having methylation greater than the median value, adjusting for age, secondhand smoke exposure before age 20, current smoking status, and estrogen receptor status. It was</p>
18	C. L. Callahan et al.	2018	<i>Lifetime exposure to ambient air pollution and methylation of tumor suppressor genes in breast tumors</i> , Environmental Research 161 (2018) 418–424	

a/a	Authors	Year	Title	Methodology & Results
19	S. Singh et al.	2012	<i>Influence of CYP2C9, GSTM1, GSTT1 and NAT2 genetic polymorphisms on DNA damage in workers occupationally exposed to organophosphate pesticides</i> , Mutation Research 741 (2012) 101–108	observed suggestive evidence that exposure to ambient air pollution throughout life, measured as TSP and TE, may be associated with DNA methylation of some tumor suppressor genes in breast tumor tissue. Future studies with a larger sample size that assess methylation of more sites are warranted. The present study was designed to determine the influence of CYP2C9, GSTM1, GSTT1 and NAT2 genetic polymorphisms on DNA damage in workers occupationally exposed to OPs. There were examined 268 subjects including 134 workers occupationally exposed to OPs and an equal number of normal healthy controls. The DNA damage was evaluated using alkaline comet assay and genotyping was done using individual polymerase chain reaction (PCR) or polymerase chain reaction–restriction fragment length polymorphism (PCR–RFLP). The results of this study suggest that GSTM1 null genotypes, and an association of NAT2 slow acetylation genotypes with CYP2C9*3/*3 or GSTM1 null genotypes may modulate DNA damage in workers occupationally exposed to OPs.
20	W. Hu et al.	2017	<i>Heavy metals in intensive greenhouse vegetable production systems along Yellow Sea of China: Levels, transfer and health risk</i> , Chemosphere 167 (2017) 82e90	In this study, the accumulation, health risk and threshold values of selected heavy metals were evaluated systematically. A total of 120 paired soil and vegetable samples were collected from three typical intensive GVP systems along the Yellow Sea of China. Mean concentrations of Cd, As, Hg, Pb, Cu and Zn in greenhouse soils were 0.21, 7.12, 0.05, 19.81, 24.95 and 94.11 mg kg ⁻¹ , respectively. Compared to rootstalk and fruit vegetables, leafy vegetables had relatively high concentrations and transfer factors of heavy metals. The relatively lower transfer factors of rootstalk and fruit vegetables and higher STVs suggest that these types of vegetables are more suitable for cultivation in greenhouse soils. This study will provide an useful reference for controlling heavy metals and developing sustainable GVP.
21	G. Ding et al.	2012	<i>Increased levels of 8-hydroxy-2'-deoxyguanosine are attributable to organophosphate pesticide exposure among young children</i> , Environmental Pollution 167 (2012) 110e114	A study on 268 young Shanghai children was conducted to examine the relationship between organophosphate pesticide (OP) exposure and a biomarker of oxidative DNA damage. Urine samples were analyzed for five non specific dialkyl phosphate (DAP) metabolites [dim ethyl phosphates (DMs) and diethyl phosphates (DEs)] and 8-hydroxy-2'-deoxyguanosine (8-OHdG). In summary, the exposure of children to OPs was associated with the increased generation of 8-OHdG, suggesting that exposure to OPs may play an important role in oxidative damage in children. Given the potential implication of these results to public health, additional longitudinal research should be conducted to evaluate the risks of oxidative stress in terms of health outcomes
22	A. Saad-Hussein et al.	2017	<i>GSTP1 and XRCC1 polymorphisms and DNA damage in agricultural workers exposed to pesticides</i> , Mutat Res Gen Tox En 819 (2017) 20–25	Here it was studied the prevalence of GSTP1 and XRCC1 polymorphisms and their possible correlation with DNA damage following prolonged pesticide exposure. DNA damage was estimated by the comet assay in peripheral blood samples from 51 pesticide-exposed workers and 50 controls. GSTP1 (105) and XRCC1 (399 and 194) genotypes were identified by restriction fragment length analysis. Consequently Individuals carrying the GSTP1 Ile-Ile or XRCC1399 Arg-Arg genotypes showed greater DNA damage than observed for other alleles.

1.5. Related Work for Environmental Centers

There are studies, as is presented in Table 5 that referred to environmental centers where measuring and monitoring key environmental variables and in collaboration with authorities supervise compliance with provisions and regulations [117-126, 128-139].

Table 5. Literature review of methods related to established environmental centers.

a/a	Authors	Year	Title	Methodology & Results
1	M. S. El-Shahawi et al.	2010	<i>An overview on the accumulation, distribution, transformations, toxicity and analytical methods for the monitoring of persistent organic pollutants</i> , Talanta 80 (2010) 1587–1597.	In this important approach a comprehensive review with 108 references referring to the distribution, source, accumulation, transformation, types and toxicity of polychlorinated biphenyls (PCBs) and organochlorine pesticides (OCPs) is presented. The review also aimed to highlight on the current best practices for the analysis of PCBs and OCPs with the signing of the Stockholm convention on POPs and the development of global monitoring programs, there is an increased need for laboratories in developing countries to determine such class of chemicals. A major focus revealed the need for low cost methods that can be implemented easily in developing countries such as electrochemical techniques.
2	Ramasamy Rajamanickam, S. Nagan,	2018	<i>Assessment of Comprehensive Environmental Pollution Index of Kurichi Industrial Cluster, Coimbatore District, Tamil Nadu, India – a Case Study</i> , Journal of Ecological Engineering Volume 19, Issue 1, January 2018, pages 191–	In India the Central Pollution Control Board (CPCB) has brought out revised criteria for evaluation of CEPI by replacing the criteria issued in 2010. According to the present study the CEPI score is below 70 which imply that the industrial units are operating and maintaining the pollution control measures consistently. However, taking a policy decision based on the CEPI score, researchers should be cautious on the adequacy of data and the parameters selected.

a/a	Authors	Year	Title	Methodology & Results
			199	
3	J. S. Horsburgh et al.,	2011	<i>Components of an environmental observatory information system</i> , Computers & Geosciences 37 (2011) 207–218	In this paper, is in details described the architecture and functional requirements for an environmental observatory information system that supports collection, organization, storage, analysis, and publication of hydrologic observations. The components demonstrated comprise an observatory information system that enables not only the management, analysis, and synthesis of environmental observations data for a single observatory, but also publication of the data on the Internet in simple to use formats that are easily accessible, discoverable by others, and interoperable with data from other observatories.
4	Keller et al.,	2015	<i>A Unified Spatiotemporal Modeling Approach for Predicting Concentrations of Multiple Air Pollutants in the Multi-Ethnic Study of Atherosclerosis and Air Pollution</i> , Environmental Health Perspectives • volume 123 number 4 April 2015	According to the present study, monitoring data obtained from regulatory networks and supplemented those data with study-specific measurements collected from MESA Air community locations and participants' homes. In each region, we applied a spatiotemporal model that included a long-term spatial mean, time trends with spatially varying coefficients, and a spatiotemporal residual. The mean structure was derived from a large set of geographic covariates that was reduced using partial least-squares regression. This novel spatiotemporal modeling approach provides accurate fine-scale predictions in multiple regions for four pollutants. There have been generated participant-specific predictions for MESA Air to investigate health effects of long-term air pollution exposures. These successes highlight modeling advances that can be adopted more widely in modern cohort studies.
5	Kumar et al.,	2015	<i>The rise of low-cost sensing for managing air pollution in cities</i> , Environment International 75, 2015, 199–205	Conventional approaches to air quality monitoring are based on networks of static and sparse measurement stations. However, these are prohibitively expensive to capture tempo-spatial heterogeneity and identify pollution hotspots, which is required for the development of robust real-time strategies for exposure control. This study illustrates the drivers behind current rises in the use of low-cost sensors for air pollution management in cities, while addressing the major challenges for their effective implementation
6	G. Hoek et al.,	2008	<i>A review of land-use regression models to assess spatial variation of outdoor air pollution</i> , Atmospheric Environment 42 (2008) 7561–7578	This paper provided a critical review of the different components of LUR models. There were identified 25 land-use regression studies. Land-use regression combines monitoring of air pollution at typically 20–100 locations, spread over the study area, and development of stochastic models using predictor varModels that include a spatial and a temporal component are of interest for (e.g. birth cohort) studies that need exposure variables on a finer temporal scale. Finally, there is a strong need for validation of LUR models with personal exposure monitoring.
7	Ozgur Kisi, Kulwinder Singh Parmar,	2016	<i>Application of least square support vector machine and multivariate adaptive regression spline models in long term prediction of river water pollution</i> , Journal of Hydrology Volume 534, March 2016, Pages 104-112	This study investigated the accuracy of least square support vector machine (LSSVM), multivariate adaptive regression splines (MARS) and M5 model tree (M5Tree) in modeling river water pollution. Various combinations of water quality parameters, Free Ammonia (AMM), Total Kjeldahl Nitrogen (TKN), Water Temperature (WT), Total Coliform (TC), Fecal Coliform (FC) and Potential of Hydrogen (pH) monitored at Nizamuddin, Delhi Yamuna River in India were used as inputs to the applied models. Results indicated that the LSSVM and MARS models had almost same accuracy and they performed better than the M5Tree model in modeling monthly chemical oxygen demand (COD). The overall results indicated that the MARS and LSSVM models could be successfully used in estimating monthly river water pollution level by using AMM, TKN and WT parameters as inputs.
8	G. Prud'homme et al.,	2013	<i>Comparison of remote sensing and fixed-site monitoring approaches for examining air pollution and health in a national study population</i> , Atmospheric Environment 80 (2013) 161e171	In this study there were examined associations between air pollution and adverse respiratory and allergic health outcomes using multi-year averages of NO2 and PM2.5 from RS and from regulatory monitoring. RS estimates were derived using satellite measurements from OMI, MODIS, and MISR instruments. Regulatory monitoring data were obtained from Canada's National Air Pollution Surveillance Network. The consistency between risk estimates based on RS and regulatory monitoring as well as the associations between air pollution and health among participants living outside the catchment area for regulatory monitoring suggest that RS can provide useful estimates of long-term ambient air pollution in epidemiologic studies. This is particularly important in rural communities and other areas where monitoring and modeled air pollution data are limited or unavailable
9	Tamás Fráter et al.,	2015	<i>Unmanned Aerial Vehicles in Environmental Monitoring—An Efficient Way for Remote Sensing</i> , Journal of Environmental Science and Engineering A 4 (2015) 85-91	In this recent experimental work, aerial photos were made in Bakony Mountains using three UAVs equipped with small HD (high definition) cameras; resolution: 1,280 × 720 pixels. The airborne surveillance of areas of ragweed (<i>Ambrosia</i> sp.) populations was also investigated. It was found that both UAVs are feasible for these tasks, and the application of these platforms for environmental monitoring is advantageous, especially in case of natural reserve areas since those are very silent and (contrary to big aircrafts and helicopters) do not disturb the ecology even in natural reserve areas and the people living there. Moreover, those could be

a/a	Authors	Year	Title	Methodology & Results
10	Ozgur Kisi, Kulwinder Singh Parmar, Kirti Soni, Vahdettin Demir,	2017	<i>Modeling of air pollutants using least square support vector regression, multivariate adaptive regression spline, and M5 model tree models</i> , Air Quality, Atmosphere & Health September 2017, Volume 10, Issue 7, pp 873–883	operated in a very flexible and economic way, and the aerial photos taken are highly informative This study investigated the applicability of three different soft computing methods, least square support vector regression (LSSVR), multivariate adaptive regression splines (MARS), and M5 Model Tree (M5-Tree), in forecasting SO ₂ concentration. According to the comparison, LSSVR provided better accuracy than the other models, while the MARS model was found to be the second best model in forecasting monthly SO ₂ concentration. Results indicated that the applied models gave better forecasting accuracy in Janakpuri station than the other stations. The results were also compared with previous studies and satisfactory results were obtained from three methods in modeling SO ₂ concentrations
11	Arshia Chander et al.,	2013	<i>A new eye in the sky: Eco-drones</i> , Environmental Development Volume 7, July 2013, Pages 155-164	According to the present study, lightweight and easy to transport. Low-cost high resolution images Low-cost operations can fly at variety of altitudes depending on data collection needs can map areas not accessible by car, boat, etc. on an on-demand time schedule. Video recording capabilities. Quick availability of raw data. Limited flight time depending on model. Limited by camera weight. Air space limitations and restrictions can be limited by wind speed and gusts. Limited amount of appropriate software. Time intensive to create orthomosaics with minimal geographic reference errors. Due to small image footprint, numerous images must be captured
12	G. Di Stefano et al.,	2018	<i>The Lusi drone: A multi-disciplinary tool to access extreme environments</i> , Marine and Petroleum Geology 90 (2018) 26e37	A multipurpose drone has been designed and constructed to access and sample extreme environments. Gas, water, and mud sampling is coupled with temperature measurements, video records, photogrammetry, infra-red, and gas distribution mapping. Successful missions have been completed at the active Lusi eruption site. The drone is an excellent tool to study harsh or unreachable sites where conventional operations are too expensive, dangerous or impossible.
14	José I. Suárez et al.,	2018	<i>Bluetooth Electronic Nose for Odour Monitoring and Control</i> , Chemical Engineering transactions, Vol. 68, 2018	A novel miniaturized prototype of an electronic nose, which includes commercial MEMS gas sensors for odour recognition, has been presented. It also includes a temperature and humidity sensor, which is often omitted in the design of many electronic noses. The use of a Bluetooth module enables the e-nose communications with a smartphone, where data are transmitted on-the-fly and stored for later processing. The results from the application of the leave-one-out cross-validation technique show that the systems has a very high success rate (close to 98%) in the pollutant discrimination at different gas concentration.
15	N. Castell et al.,	2017	<i>Can commercial low-cost sensor platforms contribute to air quality monitoring and exposure estimates?</i> , Environment International 99 (2017) 293–302	An exhaustive evaluation of 24 identical units of a commercial low-cost sensor platform against CEN (European Standardization Organization) reference analysers, evaluating their measurement capability over time and a range of environmental conditions. Results show that their performance varies spatially and temporally, as it depends on the atmospheric composition and the meteorological conditions.
16	A. Moreno-Rangel et al.,	2018	<i>Field evaluation of a low-cost indoor air quality monitor to quantify exposure to pollutants in residential environments</i> , Journal of Sensors Sensor Systems, 7, 373–388, 2018	This paper presents a user study to assess the precision, accuracy, and usability of a low-cost indoor air quality monitor in a residential environment to collect data about the indoor pollution. The findings suggest that Foobot is sufficiently accurate for identifying high pollutant exposures with potential health risks and for providing data at high granularity and good potential for user or scientific applications due to remote data retrieval. It may also be well suited to remote and larger-scale studies in quantifying exposure to pollutants.
17	World Meteorological Organization (WMO)	2018	<i>Low-cost sensors for the measurement of atmospheric composition: overview of topic and future applications</i> , World Meteorological Organization (WMO)	This report considers sensors that are designed for the measurement of atmospheric composition at ambient concentrations focusing on reactive gaseous air pollutants (CO, NO _x , O ₃ , SO ₂), particulate matter (PM) and greenhouse gases CO ₂ and CH ₄ . Smaller and/or lower cost devices tend to be less sensitive, less precise and less chemically-specific to the compound or variable of interest. This is balanced by a potential increase in the spatial density of measurements that can be achieved by a network of sensors.
18	Stanislaw Anweiler, Dawid Piwowarski	2017	<i>Multirotor platform prototype for environmental monitoring</i> , Journal of Cleaner Production Volume 155, Part 1, 1 July 2017, Pages 204-211	In this application a multirotor concept was created, which assumed some executive functions i.e. hovering, environmental data acquisition or Global Positioning System movement. On the basis of these assumptions, platform components were chosen. They included: the frame, drives, electronics and software. A platform that is able to accomplish the tasks was created. All components of the multirotor have been described, materials used, mounting and connecting them, as well as the presentation of the specific device problems. Scientific value of the paper includes the guidance of cheap and efficient setup along with the applications.
19	Dieter Schwela	2012	<i>Review of Urban Air Quality in Sub-Saharan Africa Region - Air Quality profile of SSA countries</i> , Washington, DC:	This work presents methods for water quality monitoring (WQM) from traditional manual methods to more technologically advanced methods employing wireless sensor networks (WSNs) for in situ WQM. The safety of the data and the entire network in the WQM process is paramount. Issues with malicious attackers or

a/a	Authors	Year	Title	Methodology & Results
			World Bank	physical breakdown of the infrastructure, eavesdropping, and traffic analysis should be thoroughly considered in future systems. Data processing and aggregation algorithms should be developed to ensure proper data management, and biofouling, sensor drift, and underwater communication are all issues that should be considered in the development of WSNs for WQM.
20	Prashant Kumar et al.	2015	<i>The rise of low-cost sensing for managing air pollution in cities</i> , Environment International 2015 Feb; 75: 199–205	Conventional approaches to air quality monitoring are based on networks of static and sparse measurement stations. Current progress in developing low-cost micro-scale sensing technology is radically changing the conventional approach to allow real-time information in a capillary form. But the question remains whether there is value in the less accurate data they generate.
21	K. S. Adu-Manu et al.	2016	<i>Water Quality Monitoring Using Wireless Sensor Networks: Current Trends and Future Research Directions</i> , Trans. Sensor Netw. 00, 00, Article 000 (2016)	In this work, we reviewed methods for water quality monitoring (WQM) from traditional manual methods to more technologically advanced methods employing wireless sensor networks (WSNs) for in situ WQM. In particular, it was highlighted recent developments in the sensor devices, data acquisition procedures, communication and network architectures, and power management schemes to maintain a long-lived operational WQM system. Finally, according to the discussion additional open issues need to be addressed to further advance automatic WQM using WSNs.
22	M. Pule et al.	2017	<i>Wireless sensor networks: A survey on monitoring water quality</i> , Journal of Applied Research and Technology 15, Issue 6 (2017) 562–57	This work surveys the application of WSN in environmental monitoring, with particular emphasis on water quality.
23	Christopher J. Paciorek and Yang Liu	2012	<i>Assessment and Statistical Modeling of the Relationship Between Remotely Sensed Aerosol Optical Depth and PM_{2.5} in the Eastern United States</i> , 2012 HEI Research Report 167	In this study there were developed specific statistical models for integrating monitoring, satellite, and geographic information system (GIS) data to estimate monthly ambient PM _{2.5} concentrations and used those models to estimate monthly average PM _{2.5} concentrations across the eastern United States. Authors finally developed and applied statistical methods to quantify how uncertainties in exposure estimates based on ground-level monitoring data might be reduced.

1.6. Related Work for Ionizing or Non-ionizing Radiation

Many methods in the reviewed studies refer to monitoring the possible human health effects of electromagnetic fields [142, 143], or microwave radiation [144], as is presented in Table 6.

Table 6. Literature review of methods related to radiation.

a/a	Authors	Year	Title	Methodology & Results
1	I Maccà et al.	2008	<i>Occupational exposure to electromagnetic fields in physiotherapy departments. Radiation protection dosimetry</i> , 128 (2), 180-190	In this work in order to assess occupational exposure to electromagnetic fields, 11 microwave (MW), 4 short-wave diathermy and 15 magneto therapy devices were analysed in eight physiotherapy departments. Results reveal that although most areas show substantially low levels of occupational exposure to electromagnetic fields in physiotherapy units, certain cases of over-occupational exposure limits do exist
2	Gryz K. Zradziński, P. & Karpowicz J.	2015	<i>The role of the location of personal exposimeters on the human body in their use for assessing exposure to the electromagnetic field in the radiofrequency range 98–2450 MHz and compliance analysis: evaluation by virtual measurements</i> . BioMed research international, 2015.	Calculations with 256 models of exposure scenarios show that the human body has a significant influence on the results of measurements using a single body-worn exposimeter in various locations near the body ((from -96 to +133)%), measurement errors with respect to the unperturbed E-field value. However, still the uncertainty of exposure assessments using a single exposimeter remains significantly higher than the assessment of the unperturbed E-field using spot measurements.
3	Shah S. G. S., & Farrow A.	2014	<i>Systematic literature review of adverse reproductive outcomes associated with physiotherapists' occupational exposures to non-ionising radiation</i> . Journal of occupational health, 56 (5), 323-331	A systematic review of peer reviewed literature published from 1990 to 2010 in the English language searched in eight online bibliographic databases: CINAHL, EBSCOhost, ISI Web of Knowledge, Medline, OSH UPDATE, PubMed Central, ScienceDirect, and Scopus. A number of studies did not find statistically significant results to replicate associations with such adverse outcomes, and therefore further research, preferably prospective studies of cohorts of physiotherapists, is warranted
4	Karpowicz J. & Gryz K.	2013	<i>An assessment of hazards caused by electromagnetic interaction on humans present near short-wave physiotherapeutic devices of various types including hazards for users of electronic active</i>	Leakage of electromagnetic fields (EMF) from short-wave radiofrequency physiotherapeutic diathermies (SWDs) may cause health and safety hazards affecting unintentionally exposed workers (W) or general public (GP) members (assisting patient exposed during treatment or presenting there for other reasons). Near capacitive applicators emitting continuous wave, the corresponding distances were: 120 cm for W or 150 cm for both-GP or

a/a	Authors	Year	Title	Methodology & Results
			<i>implantable medical devices (AIMD)</i> . BioMed research international, 2013	AIMD users.
5	Gryz K. & Krapowicz J..	2014	<i>Environmental impact of the use of radiofrequency electromagnetic fields in physiotherapeutic treatment</i> . Roczniki Państwowego Zakładu Higieny, 65 (1)	The spatial distribution of electric and magnetic field strength was investigated near 3 capacitive short-wave and 3 long-wave diathermies and 3 ultrasound therapy units, as along with the capacitive electric currents caused by electromagnetic field interaction in the upper limbs of the physiotherapists operating these devices. The strongest environmental electromagnetic hazards occur near short-wave diathermy devices, and to a lesser degree near long-wave diathermy devices, but were not found near ultrasound therapy units
6	C. Koutsojannis et al.	2018	<i>Microwave diathermy in physiotherapy: Introduction and evaluation of a quality control procedure</i> , Radiation Protection Dosimetry (2018), Vol. 181, No. 3, pp. 229–239	Microwave diathermies (MWDs) are electromagnetic (EM) radiation emitting systems that are used by physiotherapists for thermotherapy treatment. The results of a survey in Greece revealed serious concerns about the safety of users and coexisting patients. The proposed approach could result in the introduction of EM-screened rooms, ensuring that MWD users and other persons in the vicinity will not be exposed to EM radiation over reference levels.
7	Stacy Eltiti et al.	2007	<i>Does Short-Term Exposure to Mobile Phone Base Station Signals Increase Symptoms in Individuals Who Report Sensitivity to Electromagnetic Fields? A Double-Blind Randomized Provocation Study</i> , Environmental Health Perspectives, Vol. 115, No. 11	Fifty-six self-reported sensitive and 120 control participants were tested in an open provocation test. Of these, 12 sensitive and 6 controls withdrew after the first session. The remainder completed a series of double-blind tests. Subjective measures of well-being and symptoms as well as physiological measures of blood volume pulse, heart rate, and skin conductance were obtained. Short-term exposure to a typical GSM base station-like signal did not affect well-being or physiological functions in sensitive or control individuals.
8	Sabine J. Regel et al.	2006	<i>UMTS Base Station-like Exposure, Well-Being, and Cognitive Performance</i> , Environmental Health Perspectives, 114 (8): 1270–1275	A total of 117 healthy subjects (33 self-reported sensitive, 84 non sensitive subjects) participated in the study. There were assessed well-being, perceived field strength, and cognitive performance with questionnaires and cognitive tasks and conducted statistical analyses using linear mixed models. Organ-specific and brain tissue-specific dosimetry. No conclusions can be drawn regarding short-term effects of cell phone exposure or the effects of long-term base station-like exposure on human health.
9	P. C. Huang et al.	2018	<i>Association between media coverage and prevalence of idiopathic environmental intolerance attributed to electromagnetic field in Taiwan</i> , Environmental Research 161 (2018) 329–335	From 2007 to 2012, the other potential affecting factors such as density of mobile phone base stations, number of mobile phone users, total mobile phone calling time, and number of text messages sent through mobile phones all increased in Taiwan. This finding indicated a positive association between media coverage and the prevalence of IEI-EMF in Taiwan, which might also be true in other countries.
10	Aaron Reuben; Avshalom Caspi, Daniel W. Belsky, et al.	2017	<i>Association of Childhood Blood Lead Levels With Cognitive Function and Socioeconomic Status at Age 38 Years and With IQ Change and Socioeconomic Mobility Between Childhood and Adulthood</i> , Jama Psychiatric 171; 317 (12): 1244-1251	A prospective cohort study based on a population-representative 1972-1973 birth cohort from New Zealand; the Dunedin Multidisciplinary Health and Development Study observed participants to age 38 years (until December 2012). A direct association between greater blood lead levels and a decline in IQ and socioeconomic status from childhood to adulthood was observed with 40% of the association with downward mobility mediated by cognitive decline from childhood. Childhood lead exposure may have long-term ramifications.

Thus based on the above studies, is necessary for the pollution monitoring the establishing and management an online intelligent environmental observation system for monitoring and evaluating public health hazard from human exposure to environmental (indoor and outdoor) pollutants.

According to the previous works for this pilot Environmental Observatory (EO) model, we chose the area of Western Achaea, in Western Greece region, as fulfills all the conditions in order to be a representative location for the EO simulation model. In this area are located urban centers, an industrial zone, cultural, religious and traditional “sea and sun” mass-tourism in an annual base. There is a large wastewater treatment plant, near Peiros river and CAST, while within the administrative boundaries is located the military and civilian airport. The geomorphological and

hydrogeological bas-relief comprises: Peiros and Larisos river basin.

2. Research Methodology

2.1. Aim of the Study

For this pilot Environmental Observatory (EO) model, we chose the area of Western Achaea, in Western Greece region, as fulfills all the conditions in order to be a representative location for the EO simulation model. In this area are located urban centers, an industrial zone, cultural, religious and traditional “sea and sun” mass-tourism in an annual base. There is a big unit of a biological sewage treatment near Peiros river and CAST, while within the administrative

boundaries is located the military and civilian airport. The geomorphological and hydrogeological bas-relief comprises: Peiros and Larisos river basins (with their estuary in Gulf of Patras and Ionian Sea), large agricultural plains, high-plains, mountain areas, intermittent and ephemeral streams. The coastal forest Strofyliia along with Kotychi lagoon, are part of the Strofyliia National Park (organized in 2009) also of great importance. The forest takes up about 5,500 acres and borders the Kotychi lagoon, the marsh of Lamia, the Prokopos lake and the Ionian Sea. The protected (Ramsar convention, Natura 2000, Life) ecosystem has concentrations of brackish and fresh water, while the forest, together with the nearby lagoon, make up an important and vibrant ecosystem, characterized as a refuge of wild life, a home to many species.

The objective of this study constitutes the search and recording, selected through the international literature, case studies, operation of environmental observation centers that monitor and record the environmental pollutants in waters (lagoon, rivers, seaside), soil and air. In the end, through the extensive study of all good practices, the environmental observatories centers and also the reviews of how the effects of environmental pollution on the human health will end up to the best practice. With this optimum result the goal is to create and establish a modern intelligent environmental observatory (I. E. O.). If this model succeed in Western Greek Region then it could be applied to the whole Greek territory.

In the present work, there has been an in-depth and thorough survey in the international literature, for similar methodologies (related works) and also new techniques used in environmental observatories and research centers/institutions, worldwide, regarding to the detection, monitoring, management and reporting the environmental pollutants (with unknown toxic or radioactive action) in soil, vegetation, air, water and human body. This is accomplished with the development and implementation of all modern and traditional sampling methods, analyses and interpretation of parametric values, in combination with the use of high technology equipment. Below follows, a brief review of extant literature on the various methodologies and models according to the categories: air, soil, waters, human health, radiation as in details presented in Table 1-6.

2.2. Model Development

An implementation of laboratory testing of water samples, air samples, soil samples selected from various locations (natural resources/sources, natural recipients and areas of human installations or activities of high pollution hazard), at diverse times and on different days of week. Due account shall be given to pollutant measured values in various locations with a history (eg. Industrial zone, airport, limestone quarry) of the most dangerous toxic pollutants, in particular dioxins and furans (Ketones, ultrafine particles PM10, PM2.5, NO_x, PAHs, Na, NO⁻³, SO₄⁻², Cl⁻ and NH₄⁺, O₃, SO_x, VOCs) as well as heavy metals (eg Al, Cu, Zn, Ag, Cd, As, Hg, BaP, Cr, Sb, BaA, BbF), as well as levels of non-

ionizing or ionizing radiation.

Therefore an installation of small measurement stations using accurate continuous measurement systems shall significantly reduce personnel, equipment and financial resources requirements included in the laboratory context, is planned. With smart technology (drones) and wireless sensor platforms, equipped with multiple sensors able to measure the most relevant water quality parameters [pH, dissolved oxygen-DO, oxidation-reduction potential-ORP, conductivity/salinity, turbidity, temperature and dissolved ions (F⁻, Ca⁺², NO⁻³, Cl⁻, I⁻, Cu⁺², Br⁻, Ag⁺, BF⁻⁴, NH₄, Li⁺, Mg⁺², NO⁻², ClO₄, K⁺, Na⁺), is feasible water monitoring for chemical leakage detection in rivers, lakes, streams, lagoon and levels of seawater pollution. industrial area and, with system of remotely notice, so that is located immediately each reject of sewages and are held immediately sampling and complete analysis. Important is the role of drones equipped with specific type of sensors and the ability of smart sampling or testing of environmental samples ranging from water, soil to air from sea, rivers, lagoon and atmosphere. The exported results will be expressed through certain indicators of pollution (hybrid pollution index) per category (soil, water, air) which will characterize the environmental quality of a given place (With the algorithm of source, the path, and receptor).

We decided that in this study we should design our methodology research using properly "mixed methods" thus according Cresswell (2003, p. 5) "...provides a better understanding of research problems than either approach alone". We conducted a thorough review of the existing literature on the subject and the worldwide environmental centers. Aim is the foundation and operation of a Smart Environmental Observation Centre model. The process of monitoring and sampling collection (automatically or manually) will provide us with the important and critical data for management (the information that they will be taken with conventional or technical way. By the analysis results of the toxicity indicators and the environmental hazards of pollutants, the climatic and meteorological data, in combination with the satellite photographs (image analysis) and the wireless monitoring via portable devices, gives useful conclusions on the current threat level of the environmental pollutants reported by individuals. Moreover the use of the artificial intelligence (AI) and simulators of human body (whole body phantom models) attempts a more accurate qualitative and quantitative (worst-best scenario) forecast. Thus we receive answers we are seeking about how many people are exposed to the environmental pollution and the severity of a medium/long-term situation. In this way with the exploitation of statistical analysis software, precious conclusions can be exported regarding to the future health of residents (possible event of illnesses, allergies, autoimmune diseases of in-depth time) according to the age, the sex, the social and professional order, their activities or their house location. Finally we can evaluate the areas where inhabitants live with poor medium or high well-being.

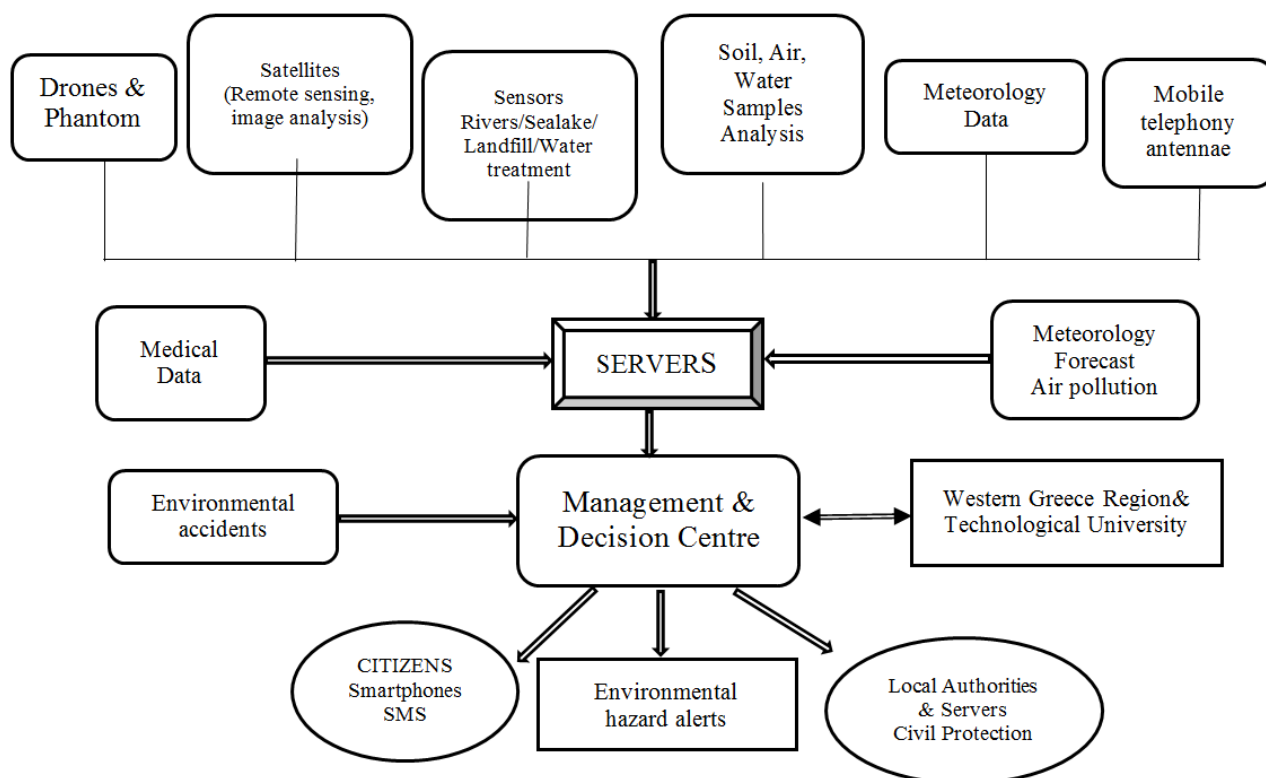


Figure 1. The proposed ENVIRONMENTAL OBSERVATION CENTRE model.

2.3. Overview of the Pilot Study

Environmental measurement includes data collection activity or investigation involving the assessment of chemical, physical, or biological factors in the environment which affect the environment, human health or the quality of life. Monitoring (including laboratory testing) and measuring (passive and active sampling) of waste (waste composition, landfill gases and leaks) noise, air, water, soil and sediments pollution, ionizing and not ionizing radiation, is necessary in order to assess the extent of the project's compliance with national regulations, quality standards and laws. According to the World Health Organization, prolonged exposure to pollution can lead to serious health effects. Long and short term exposure to toxicants has a different toxicological impact on human including the eyes irritation, skin diseases, etc. Most long-term chronic diseases such as cancer respiratory and cardiovascular diseases, neuropsychiatric complications Alzheimer disease, Parkinson disease. Pollutants mediated by the human endocrine system and by the brain, such as sleep disturbance, cardiovascular diseases, annoyance (a feeling of discomfort affecting general well-being), cognitive impairment and mental health problems will exist the estimate and forecast with regard to how many they medium- or long-term can immediately or indirectly, (in

the near term, and in total) they overload and harm the health of persons. Will exist the possibility of equitable management of the smart platform model from the Region of Western Greece in close collaboration with Technological University of Western Greece and the Municipalities, from a strictly determined team of professors, scientists and executives of public administration. The results of measurements, in combination with the short and medium-term "ecological forecast" for the potential spread of pollution (chemical gas plume, spreading of pollution in waters, etc), will constitute a tool for a rational strategic planning. The implementation of targeted actions for health promotion, concretization of environment protection policies and crises management will be of crucial importance. Furthermore, they will contribute considerably in the strategic planning and in the decision-making critical political, regarding the infrastructures, the investments and in general the development in all sectors (primary, secondary etc) and into research or technological human activities. With the systematic residents' health monitoring, are ensured its quality upgrade and their well-being. Finally, it can constitute a field of education of new scientists and executives of public institutions but also exchange of know-how with scientists from the Hellenic space and from all world.

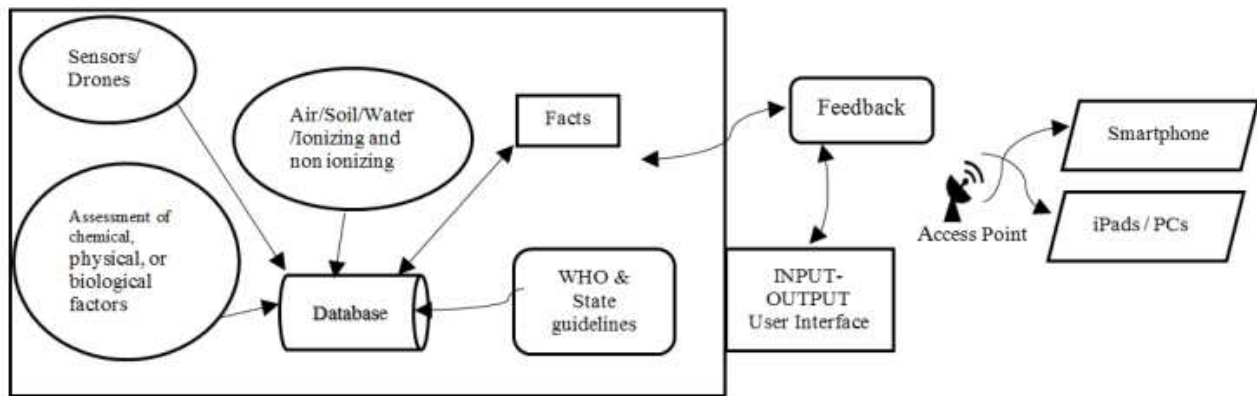


Figure 2. General Structure of intelligent management and decision centre.

3. Results and Discussion

Following the extended literature research that was presented above, this new model of Intelligent Environmental Monitoring and Management System (IEMMS) will be completely functional and it will give per passes moment (online) precise elements for the all environmental parameters (physicochemical, microbiological, electromagnetic and other radiation, dust, noise, satellite data, geography, geology) that they are transmitted wireless by their tens stations of measurement at the same type as presented in [6, 7] approaches. The collected data will be analyzed automatically as presented in [7] systems.

With the application of technology (Artificial Intelligence), we will succeed simulation of human body and its operations in the measured environmental values and impacts. A modern environmental observatory that will also function as environmental management and decision support model, with regard to the effects of pollution on human health.

The parameter values for various pollutants in each region and its natural and microbiological characteristics use of powerful software of statistical analysis and treatment of big data can link to useful conclusions on the tendency of pollution (per region) and the impact of these pollutants on human body.

Monitoring, recording and analysis of the dangerous and toxic for human health, physicochemical and microbiological pollutants, could constitute a medium-term or long-term tool for the ecological planning of young person house of model of growth of modern Municipality as presented in [60] and according to [126, 127] approaches. For example, this model (prototype) it would be feasible to propose a more rational “clean” primary, secondary and tertiary sector development, with the imaging in a kind of an “*Environmental Pollution Chart*” map. The purpose of such a map would be the aid in the prevention of health of residents with the evasion of report of these in charged with environmental pollutants regions as presented in [117, 118, 122] models.

In the modern developed states, the “ecological forecast” could contribute considerably in the strategic planning and in the decision-making critical regarding infrastructures and investments in the rural sector, in the tourism, in the culture,

in the trade even in the athletic installations and activities, contributing with the better way in the upgrade of inhabitants’ quality or way of life, either they visit or they go through the different areas within the range of the Smart Environmental Observatory as presented in [32, 126] approaches.

Finally, under the proposed approach, data acquisition, processing and analysis of measured values for various kinds of pollutants from environmental overloaded surfaces, useful conclusions are drawn regarding to the “pollution tendency” in every different area and the possible effects on human in combination with geography and geomorphology. With the use of Big Data approach and AI technologies in human body simulators (whole body phantom models) combined with regional established death reports, we intend to make a more accurate qualitative and quantitative forecast: worst-best scenario, about as the life quality for residents -who may be exposed to the pollutants- as the direct or indirect medium to long-term adverse effects [28, 137].

4. Conclusions

Our inference is that the best way to accomplish a reliable and effective study is follow a combination of various methodologies of quantitative and qualitative research. We therefore conclude that, the most appropriate methods in our study are a mixture of qualitative, quantitative research, longitudinal and cross-sectional research and classification research [1, 5, 8, 11, 13, 21, 23, 29, 32, 33, 42, 48, 52, 53, 76, 79, 91, 92, 95, 98, 106, 113, 124, 126, 129, 136, 140, 142].

The precious conclusions drawn up by the course of residents’ health (potential illnesses, allergies, autoimmune diseases over time) regarding to age, sex, social and professional class, activities and the place of residence as presented in [119] approach. In fact, it renders easier the environmental monitoring programs, the confrontation of problems and the diffusion of information. Furthermore, it becomes more effective and efficient for the citizens benefit along with officials, researchers, scientists, students, institutes ecc. Environmental footprints already include local or global supply chains when they show us the impacts of air, water, soil pollution or radiation. But what if in addition to showing you

how many mgrs of contaminants, heavy metals or even pesticide exposure and adverse health effects at the clinical, hematological and biochemical level, pollution causes, the footprint came with maps/charts showing where that pollution is driving citizens' health? With pollutants footprints the prediction of increasing pollution, will provide us with critical informations and permit a better management, with the use of functional analysis tools such as GIS [21, 24, 28, 79].

References

- [1] Blades, E., Naidu, R. P., & Mathison, G. E. (1998). *The microbiological analysis of Sahara dust and its association with asthma in Barbados*. West Indian Med. J, 47 (suppl. 2), 34-5.
- [2] Finkelman, R. B. (2019). *The influence of clays on human health: A medical geology perspective*. Clays and Clay Minerals, 67 (1), 1-6.
- [3] Iturburu, F. G., Calderon, G., Amé, M. V., & Menone, M. L. (2019). *Ecological Risk Assessment (ERA) of pesticides from freshwater ecosystems in the Pampas region of Argentina: Legacy and current use chemicals contribution*. Science of The Total Environment, 691, 476-482.
- [4] Boone, J. S., Vigo, C., Boone, T., Byrne, C., Ferrario, J., Benson, R.,... & Glassmeyer, S. T. (2019). *Per-and polyfluoroalkyl substances in source and treated drinking waters of the United States*. Science of the Total Environment, 653, 359-369.
- [5] Eleftheria Chalvatzaki, Thodoros Glytsos & Mihalis Lazaridis, *A methodology for the determination of fugitive dust emissions from landfill sites*, International Journal of Environmental Health Research, 2015, Vol. 25, No. 5, 551-569.
- [6] Ashok Kumar, Naveen K. Bellam, Anupma Sud, *Performance of an industrial source complex model: Predicting long-term concentrations in an urban area*, Environmental Progress 2004, Vol. 18. Issue 2, pp. 93-100.
- [7] Victoria Aleksandropoulou & Mihalis Lazaridis, *Development and application of a model (ExDoM) for calculating the respiratory tract dose and retention of particles under variable exposure conditions*, Air Qual Atmos Health (2013) 6: 13-26.
- [8] Simon D. Griffiths et al., *A study of particulate emissions during 23 major industrial fires: Implications for human health*, Environment International 2018, Vol. 112, pp. 310-323.
- [9] K. Gyan et al., *African dust clouds are associated with increased paediatric asthma accident and emergency admissions on the Caribbean island of Trinidad*, Int J Biometeorol (2005) 49: pp. 371-376.
- [10] Chiang C, Lai C, Chou P, Li Y, and Tu, Y 1999 *ASIA - PACIFIC Conference on the Built Environment. The Study On The Comprehensive Indicators Of Indoor Environment Assessment For Occupants' Health*. (Taipei, Taiwan) pp 1-7.
- [11] W H W Ibrahim1, E Marinie, J Yunus, N Asra and K Mohd Sukor, *Air quality assessment on human well-being in the vicinity of quarry site*, IOP Conf. Series: Earth and Environmental Science 117 (2018) 012010.
- [12] Athanasios Valavanidis Konstantinos Fiotakis and Thomais Vlachogianni, *Airborne Particulate Matter and Human Health: Toxicological Assessment and Importance of Size and Composition of Particles, for Oxidative Damage and Carcinogenic Mechanisms*, Journal of Environmental Science and Health Part C (2008), 26: pp. 339-362.
- [13] E. Burte et al., *Association between air pollution and rhinitis incidence in two European cohort*, Environment International 115 (2018) 257-266.
- [14] Mauro Masiol, Roy M. Harrison, *Aircraft engine exhaust emissions and other airport-related contributions to ambient air pollution: A review*, Atmospheric Environment 95 (2014) 409-455.
- [15] G. Valotto et al., *Characterization and preliminary risk assessment of road dust collected in Venice airport (Italy)*, Journal of Geochemical Exploration 190 (2018) pp. 142-153.
- [16] Chu et al., *Observing System-Terra Moderate Resolution Imaging Global monitoring of air pollution over land from the Earth Spectroradiometer (MODIS)*, J. Geophys. Res., Vol. 108 (D21), 4661 (2003).
- [17] Oscar Alvear, Nicola Roberto Zema, Enrico Natalizio, and Carlos T. Calafate, *Using UAV-Based Systems to Monitor Air Pollution in Areas with Poor Accessibility*, Journal of Advanced Transportation Volume 2017, Article ID 8204353, 14 pages.
- [18] N. S. Duzgoren-Aydin (2008), *Health Effects of Atmospheric Particulates: A Medical Geology Perspective*, Journal of Environmental Science and Health Part C, 26: 1-39, 2008.
- [19] L. M. Filimonova, A. V. Parshin V. A. Bychinskii, *Air pollution assessment in the area of aluminum production by snow geochemical survey*, Russian Meteorology and Hydrology October 2015, Volume 40, Issue 10, pp 691-698.
- [20] Zhenxv Lan, Fengyuan Zhang, Jia Wang, Min Chen, *Design and Implementation of a Dynamic Simulation System for Air Pollutant Diffusion - A Case Study of the Fangshan District, Beijing, China*, J. Geol Geosci Volume 2 (1): 2018.
- [21] D. Briggs et al., *Mapping urban air pollution using GIS: a regression-based approach*, Journal International Journal of Geographical Information Science Volume 11, 1997 - Issue 7.
- [22] H. Catherine W. Skinner, *The earth, source of health and hazards: An introduction to medical geology. Annual Review of Earth and Planetary, Sciences* 2007; 35: 177-213.
- [23] X. Peng et al. (2016). *Influence of quarry mining dust on PM_{2.5} in a city adjacent to a limestone quarry: Seasonal characteristics and source contributions*, Science of the Total Environment 550 (2016) pp. 940-949.
- [24] Inmaculada Menendez et al., (2017) *Saharan dust and the impact on adult and elderly allergic patients: the effect of threshold values in the northern sector of Gran Canaria, Spain*, International Journal of Environmental Health Research, 2017 VOL. 27, NO. 2, 144-160.
- [25] Yong Zha, Jay Gao, Jianjun Jiang, Heng Lu & Jiazhu Huang, *Normalized difference haze index: a new spectral index for monitoring urban air pollution. International Journal of Remote Sensing*, Vol. 33, No. 1, 10 January 2012, pp. 309-321.
- [26] L. Risom et al., *Oxidative stress-induced DNA damage by particulate air pollution*, Mutation Research 592 (2005) pp. 119-137.

- [27] C. A. Pope III, R. T. Burnett, M. J. Thun, E. E. Calle, D. Krewski, K. Ito, G. D. Thurston, *Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution*, JAMA 287 (2002) pp. 1132–1141.
- [28] B. Brunekreef, S. T. Holgate, *Air pollution and health*, Lancet 360 (2002) pp. 1233–1242.
- [29] T. Bellander *et al.*, *Using geographic information systems to assess individual historical exposure to air pollution from traffic and house heating in Stockholm*, Environmental Health Perspectives VOLUME 109 | NUMBER 6 | June 2001.
- [30] S. L. Penn *et al.*, *Modeling variability in air pollution-related health damages from individual airport emissions*, Environmental Research 156 (2017) pp. 791–800.
- [31] Jerrett, M. *et al.* (2009), *Long-term ozone exposure and mortality*. New Engl. J. Med. 360 (11), 1085–1095.
- [32] Colin Wong and Rachel Wyles, *Mapping concentrations of airborne matter to quantify the fugitive emissions discharge rate from a landfill*, Greenhouse Gas Measurement & Management 2 | 2012 | 50–60.
- [33] E. N. Papadakis *et al.*, *A pesticide monitoring survey in rivers and lakes of northern Greece and its human and ecotoxicological risk assessment*, Ecotoxicology and Environmental Safety 116 (2015) 1–9.
- [34] Tengku Ibrahim, F. Othman and N. Z. Mahmood, *Assessment of water quality of Sembilang River receiving effluent from controlled municipal solid waste (MSW) landfill in Selangor*, IOP Conf. Series: Materials Science and Engineering 210 (2017) 012019.
- [35] Ujianti, R. M. D., Anggoro, S., Bambang, A. N., & Purwanti, F. (2018, May). *Water quality of the Garang River, Semarang, Central Java, Indonesia based on the government regulation standard*. In Journal of Physics: Conference Series (Vol. 1025, No. 1, p. 012037). IOP Publishing.
- [36] A. Allahyar and M. R. Sabour M R (2014), *Multi-response optimization of Fenton process for applicability assessment in landfill leachate treatment*, Waste Management 34 2528–2536.
- [37] Abunama, T., Othman, F., Alslaibi, T., & Abualqumboz, M. (2017). *Quantifying the Generated and Percolated Leachate through a Landfill's Lining System in Gaza Strip, Palestine*. Polish Journal of Environmental Studies, 26 (6).
- [38] D. L. Jones, K. L. Williamson and A. G. Owen (2006), *Phytoremediation of landfill leachate*, Waste Management 26 825–837.
- [39] T. Eggen, M. Moeder and A. Arukwe (2010), *Municipal landfill leachates: A significant source for new and emerging pollutants*, Science of the Total Environment 408 5147–5157.
- [40] A. Fernandes, M. J. Pacheco, L. Ciriaco and A. Lopes (2015), *Review on the electrochemical processes for the treatment of sanitary landfill leachates: Present and future*, Applied Catalysis B: Environmental 176–7 183–200.
- [41] Muhammad Umar, H. Abdul Aziz and M. S. Yusoff (2010), *Variability of parameters involved in leachate pollution index and determination of LPI from four landfills in Malaysia*, International Journal of Chemical Engineering 1–6.
- [42] N. Yusof, A. Haraguchi, M. A. Hassan, M. R. Othman, M. Wakisaka and Y. Shiraj (2009), *Measuring organic carbon, nutrients and heavy metals in rivers receiving leachate from controlled and uncontrolled municipal solid waste (MSW) landfills*, Waste Management 2666–2680.
- [43] Jiang M, Zeng G, Zhang C, Ma X, Chen M, *et al.* (2013), *Assessment of Heavy Metal Contamination in the Surrounding Soils and Surface Sediments in Xiawangang River, Qingshitang District*, PLoS ONE 8 (8): e71176.
- [44] Pradip Kumar Maurya and D. S. Malik (2018), *Bioaccumulation of heavy metals in tissues of selected fish species from Ganga river, India, and risk assessment for human health*, Human and Ecological Risk Assessment.
- [45] C. D. Kassotis *et al.*, *Characterization of Missouri surface waters near point sources of pollution reveals potential novel atmospheric route of exposure for bisphenol A and wastewater hormonal activity pattern*, Science of the Total Environment 524–525 (2015) 384–393.
- [46] Krishna Woli, Toshiyuki Nagumo Ryusuke Hatano, *Magnitude of Nitrogen Pollution in Stream Water due to Intensive Livestock Farming Practices*, Soil Science and Plant Nutrition 48 (6): 883–887.
- [47] Stavroula Galanopoulou, Andreas Vgenopoulos, Nikolaos Conispoliatis, *DDTs and other chlorinated organic pesticides and polychlorinated biphenyls pollution in the surface sediments of Keratsini harbour, Saronikos gulf, Greece*, Marine Pollution Bulletin Volume 50, Issue 5, May 2005, Pages 520–525.
- [48] I. K. Konstantinou *et al.*, *The status of pesticide pollution in surface waters (rivers and lakes) of Greece. Part I. Review on occurrence and levels*, Environmental Pollution 141 (2006) 555e570.
- [49] K. E. Murray *et al.* (2010), *Prioritizing research for trace pollutants and emerging contaminants in the freshwater environment*, Environmental Pollution 158 (2010) 3462e3471.
- [50] M. J. Martí'nez Bueno *et al.*, *Pilot survey of chemical contaminants from industrial and human activities in river waters of Spain*, Intern. J. Environ. Anal. Chem. Vol. 90, Nos. 3–6, 15 March–15 May 2010, 321–343.
- [51] M. Gustavsson *et al.*, *Pesticide mixtures in the Swedish streams: Environmental risks, contributions of individual compounds and consequences of single-substance oriented risk mitigation*, Science of the Total Environment 598 (2017) pp. 973–983.
- [52] Jens Hartmann *et al.*, *A Brief Overview of the GLObal River Chemistry Database, GLORICH*, Procedia Earth and Planetary Science 10 (2014) 23–27.
- [53] Michael Hendryx, Jamison Conley, Evan Fedorko, Juhua Luo and Matthew Armistead (2012), *Permitted water pollution discharges and population cancer and non-cancer mortality: toxicity weights and upstream discharge effects in US rural-urban areas*, Hendryx *et al.* International Journal of Health Geographics 2012, 11: 9.
- [54] C. Aydinalp, E. A. Fitz Patrick, and M. S. Cresser, *Heavy Metal Pollution in Some Soil and Water Resources of Bursa Province, Turkey*, Communications in Soil Science and Plant Analysis, 36: pp. 1691–1716, 2005.
- [55] X. Gao *et al.*, *Hydrological controls on nitrogen (ammonium versus nitrate) fluxes from river to coast in a subtropical region: Observation and modeling*, Journal of Environmental Management 213 (2018) 382e391.

- [56] Anna Jurado, Enric Vázquez-Suñé, Jesus Carrera, Miren López de Alda, Estanislao Pujades, Damià Barceló, *Emerging organic contaminants in groundwater in Spain: A review of sources, recent occurrence and fate in a European context*, Science of The Total Environment Volume 440, 1 December 2012, Pages 82-94.
- [57] Biplob Das, Rick Nordin, Asit Mazumder, *Watershed land use as a determinant of metal concentrations in freshwater systems*, Environmental Geochemistry and Health December 2009, Volume 31, Issue 6, pp 595–607.
- [58] A. Schaeffer, H. Hollert, H. T. Ratte, M. Ross-Nickoll, J. Filser, M. Matthies, J. Oehlmann, M. Scheringer, R. Schulz, A. Seitz, An indispensable asset at risk: merits and needs of chemicals-related environmental sciences, Environ. Sci. Pollut. Res. 16 (2009) 410–413.
- [59] R. Meffe, I. de Bustamante, *Emerging contaminants in surface water and groundwater: a first overview of the situation in Italy*, Sci. Total Environ. 481 (2014) 280–295.
- [60] B. Petrie, R. Barden, B. Kasprzyk-Hordern, *A review on emerging contaminants in wastewaters and the environment: current knowledge, understudied areas and recommendations for future monitoring*, Water Res. 71 (2015) 3–27.
- [61] M. Stuart, D. Lapworth, E. Crane, A. Hart, *Review of risk from potential emerging contaminants in UK groundwater*, Sci. Total Environ. 416 (2012) 1–21.
- [62] R. W. Masters, I. M. Verstraeten, T. Heberer, *Fate and transport of pharmaceuticals and endocrine disrupting compounds during ground water recharge*, Ground Water Monit. Remediat. 24 (2004) 54–57.
- [63] L. Lamastra et al., *Inclusion of emerging organic contaminants in groundwater monitoring plans*, Methods X 3 (2016) pp. 459–476.
- [64] X. Y. Miao, J. J. Yang, C. D. Metcalfe, *Carbamazepine and its metabolites in wastewater and in biosolids in a municipal wastewater treatment plant*, Environ. Sci. Technol. 39 (19) (2005) 7469–7475.
- [65] M. Zafar and B. J. Alappat, *Landfill Surface Runoff and Its Effect on Water Quality on River Yamuna*, JOURNAL OF ENVIRONMENTAL SCIENCE AND HEALTH Part A—Toxic/Hazardous Substances & Environmental Engineering Vol. A39, No. 2, pp. 375–384, 2004.
- [66] Fakayode, S. O. (2005), *Impact assessment of industrial effluent on water quality of the receiving Alaro river in Ibadan Nigeria*, AJEAM-RAGEE 10: 1-13.
- [67] Kanu, Ijeoma and Achi, O. K. (2011), *Industrial Effluents and Their Impact on Water Quality of Receiving Rivers in Nigeria*, Journal of Applied Technology in Environmental Sanitation, 1 (1): 75-86.
- [68] Lucrezia Lamastra, Matteo Balderacchi, Marco Trevisan, *Inclusion of emerging organic contaminants in groundwater monitoring plans*, MethodsX Volume 3, 2016, Pages 459-476.
- [69] Nubi, O. A. 1 Osibanjo, O. Nubi, A. T. 2008 Impact assessment of dumpsite leachate on the qualities of surface water and sediment of river Eku, Ona-Ara local government, Oyo State, Nigeria. Science World Journal 3 (3): 17-20.
- [70] Udiba U. U., Gauje Balli, Ashade N. O., Ade-Ajayi F. A., Okezie V. C., Aji B. M. and Agboun T. D. T., *An assessment of the heavy metal status of River Galma around Dakace industrial layout, Zaria, Nigeria*, Merit Research Journal of Environmental Science and Toxicology (ISSN: 2350-2266) Vol. 2 (8) pp. 176-184, November, 2014.
- [71] Udiba U. U., Anyanwu Stella, Gauje Balli, Dawaki S. I., Oddy-Obi I. C., Agboun T. D. T. *Toxicity Potential of Allium cepa L. as a Bioindicator of Heavy Metal Pollution Status of River Galma Basin Around Dakace Industrial Layout, Zaria, Nigeria*, International Journal of Biological Sciences and Applications 2015; 2 (6): 76-85.
- [72] D. Yu et al., *Modeling increased riverine nitrogen export: Source tracking and integrated watershed-coast management*, Marine Pollution Bulletin 101 (2015) 642–652.
- [73] F. Riva et al., *Monitoring emerging contaminants in the drinking water of Milan and assessment of the human risk*, International Journal of Hygiene and Environmental Health 221 (2018) 451–457.
- [74] S. T. Glassmeyer et al., *Nationwide reconnaissance of contaminants of emerging concern in source and treated drinking waters of the United States*, Science of the Total Environment 581-582 (2017) pp. 909–922.
- [75] Christina I. Nannou, Christina I. Kosma and Triantafyllos A. Albanis, *Occurrence of pharmaceuticals in surface waters: analytical method development and environmental risk assessment*, International Journal of Environmental Analytical Chemistry, 14th Symposium on Chemistry and Fate of Modern Pesticides, Ioannina, Greece (18–21 September 2014).
- [76] J. Robles-Molina, F. J. Lara-Ortega, B. Gilbert-López, J. F. García-Reyes and A. Molina-Díaz, *Chromatogr. Multi-residue method for the determination of over 400 priority and emerging pollutants in water and wastewater by solid-phase extraction and liquid chromatography-time-of-flight mass spectrometry*, Journal of Chromatography A Volume 1350, 11 July 2014, Pages 30-43 A 1350, 30 (2014).
- [77] Cupit M, Larsson O, de Meeûs C, Eduljee GH, Hutton MC., *Assessment and management of risks arising from exposure to cadmium in fertilisers - I*, / The Science of the Total Environment 291 (2002) 167–187.
- [78] Zhongmin Jia1, Siyue Li & Li Wang, *Assessment of soil heavy metals for eco-environment and human health in a rapidly urbanization area of the upper Yangtze Basin*, SCIEnTific Reports | (2018) 8: 3256 | DOI: 10.1038/s41598-018-21569-6.
- [79] Olivier Núñez et al., *Association between heavy metal and metalloid levels in topsoil and cancer mortality in Spain*, Environ Sci Pollut Res (2017) 24: 7413–7421.
- [80] Rosemary et al., *Concentrations of Trace Metals in Selected Land Uses of a Dry Zone Soil Catena of Sri Lanka*, Tropical Agricultural Research Vol. 25 (4): 512-522 (2014).
- [81] Nisreen Tamimi, Dörte Diehl, Mohand Njoum, Amer Marei, Gabriele E. Schaumann, *Effects of olive mill wastewater disposal on soil: Interaction mechanisms during different seasons*, J. Hydrol. Hydromech., 64, 2016, 2, 176–195.
- [82] L. R. Lado et al., *Heavy metals in European soils: A geostatistical analysis of the FOREGS Geochemical database*, Geoderma 148 (2008) 189–199.

- [83] G. Tóth *et al.*, *Heavy metals in agricultural soils of the European Union with implications for food safety*, Environment International 88 (2016) 299–309.
- [84] P. Saikkonen, *Knowledge Production and Polluted Soil in Urban Planning: The Case of Helsinki*, Journal of Environmental Policy & Planning, 2015 Vol. 17, No. 5, 538–552.
- [85] Alamdar *et al.* *Organochlorine pesticides in surface soils from obsolete pesticide dumping ground in Hyderabad City, Pakistan: Contamination levels and their potential for air–soil exchange*, Science of the Total Environment 470–471 (2014) 733–741.
- [86] G. Shi *et al.* *Potentially toxic metal contamination of urban soils and roadside dust in Shanghai, China*, Environmental Pollution 156 (2008) 251–260.
- [87] Viacheslav Vasenev, Yakov Kuzyakov, *Urban soils as hot spots of anthropogenic carbon accumulation: Review of stocks, mechanisms and driving factors*, Land Degrad. Dev. 2018; 29: 1607–1622.
- [88] Peter W. Abrahams, *Soil, geography and human disease: a critical review of the importance of medical cartography*, Progress in Physical Geography 30, 4 (2006) pp. 490–512.
- [89] E. C. Brevik and T. J. Sauer, *The past, present, and future of soils and human health studies*, SOIL, 1, 35–46, 2015, www.soil-journal.net/1/35/2015/.
- [90] A. Moretto, C. Colosio, *The role of pesticide exposure in the genesis of Parkinson's disease: Epidemiological studies and experimental data*, Toxicology 307 (2013) 24–34.
- [91] A. Gebrekidan *et al.*, *Toxicological assessment of heavy metals accumulated in vegetables and fruits grown in Ginfel river near Sheba Tannery, Tigray, Northern Ethiopia*, Ecotoxicology and Environmental Safety 95 (2013) 171–178.
- [92] M. T. Baltazar *et al.*, *Pesticides exposure as etiological factors of Parkinson's disease and other neurodegenerative diseases—A mechanistic approach*, Toxicology Letters 230 (2014) 85–103.
- [93] Sharon K. Sagiv *et al.*, *Prenatal Organophosphate Pesticide Exposure and Traits Related to Autism Spectrum Disorders in a Population Living in Proximity to Agriculture*, Environmental Health Perspectives 047012, 2018.
- [94] A. Dabass *et al.*, *Systemic inflammatory markers associated with cardiovascular disease and acute and chronic exposure to fine particulate matter air pollution (PM_{2.5}) among US NHANES adults with metabolic syndrome*, Environmental Research 161 (2018) 485–491.
- [95] C. R. García-García *et al.*, *Occupational pesticide exposure and adverse health effects at the clinical, hematological and biochemical level*, Life Sciences 145 (2016) 274–283.
- [96] L. S. Engel *et al.*, *Insecticide Use and Breast Cancer Risk among Farmers' Wives in the Agricultural Health Study*, Environ Health Perspect. 2017 Sep; 125 (9): 097002.
- [97] Louis *et al.*, *A prospective study of cancer risk among Agricultural Health Study farm spouses associated with personal use of organochlorine insecticides*, Environmental Health (2017) 16: 95.
- [98] Ming Ye¹, Jeremy Beach, Jonathan W. Martin, Ambikaipakan Senthilselvan X, *Pesticide exposures and respiratory health in general populations*, Journal of Environmental Sciences 5 1 (2017) 361–370.
- [99] C. Piccoli *et al.*, *Pesticide exposure and thyroid function in an agricultural population in Brazil*, Environmental Research 151 (2016) 389–398.
- [100] J. F. Lebov *et al.*, *Pesticide exposure and end-stage renal disease risk among wives of pesticide applicators in the Agricultural Health Study*, Environmental Research 143 (2015) 198–210.
- [101] A. Gómez-Martin *et al.*, *Polymorphisms of pesticide-metabolizing genes in children living in intensive farming communities*, Chemosphere 139 (2015) 534–540.
- [102] X Rupali Das, Andrea Steege, Sherry Baron, John Beckman & Robert Harrison, (2001) *Pesticide-related Illness among Migrant Farm Workers in the United States*, Journal of Occupational and Environmental Health, 7: 4, 303–312.
- [103] S. Mostafalou, M. Abdollahi, *Pesticides and human chronic diseases: Evidences, mechanisms, and perspectives*, Toxicology and Applied Pharmacology 268 (2013) 157–177.
- [104] A. C. Edwards *et al.*, *Farmyards, an overlooked source for highly contaminated runoff*, Journal of Environmental Management 87 (2008) 551–559.
- [105] Senkayi *et al.*, *Investigation of an association between childhood leukemia incidences and airports in Texas*, Atmospheric Pollution Research (APR) 5 (2014), 189–195.
- [106] C. L. Callahan *et al.*, *Lifetime exposure to ambient air pollution and methylation of tumor suppressor genes in breast tumors*, Environmental Research 161 (2018) 418–424.
- [107] S. Singh *et al.*, *Influence of CYP2C9, GSTM1, GSTT1 and NAT2 genetic polymorphisms on DNA damage in workers occupationally exposed to organophosphate pesticides*, Mutation Research 741 (2012) 101–108.
- [108] W. Hu *et al.*, *Heavy metals in intensive greenhouse vegetable production systems along Yellow Sea of China: Levels, transfer and health risk*, Chemosphere 167 (2017) 82e90.
- [109] G. Ding *et al.*, *Increased levels of 8-hydroxy-2'-deoxyguanosine are attributable to organophosphate pesticide exposure among young children*, Environmental Pollution 167 (2012) 110e114.
- [110] A. Saad-Hussein *et al.*, *GSTP1 and XRCC1 polymorphisms and DNA damage in agricultural workers exposed to pesticides*, Mutat Res Gen Tox En 819 (2017) 20–25.
- [111] M. S. El-Shahawi *et al.*, *An overview on the accumulation, distribution, transformations, toxicity and analytical methods for the monitoring of persistent organic pollutants*, Talanta 80 (2010) 1587–1597.
- [112] Ramasamy Rajamanickam, S. Nagan, *Assessment of Comprehensive Environmental Pollution Index of Kurichi Industrial Cluster, Coimbatore District, Tamil Nadu, India – a Case Study*, Journal of Ecological Engineering Volume 19, Issue 1, January 2018, pages 191–199.
- [113] J. S. Horsburgh *et al.*, *Components of an environmental observatory information system*, Computers & Geosciences 37 (2011) 207–218.
- [114] Keller *et al.*, *A Unified Spatiotemporal Modeling Approach for Predicting Concentrations of Multiple Air Pollutants in the Multi-Ethnic Study of Atherosclerosis and Air Pollution*, Environmental Health Perspectives volume 123 | number 4 | April 2015.

- [115] Kumar et al., *The rise of low-cost sensing for managing air pollution in cities*, Environment International 75, 2015, 199–205.
- [116] G. Hoek et al., *A review of land-use regression models to assess spatial variation of outdoor air pollution*, Atmospheric Environment 42 (2008) 7561–7578.
- [117] Ozgur Kisi, Kulwinder Singh Parmar, *Application of least square support vector machine and multivariate adaptive regression spline models in long term prediction of river water pollution*, Journal of Hydrology Volume 534, March 2016, Pages 104–112.
- [118] G. Prud'homme et al., *Comparison of remote sensing and fixed-site monitoring approaches for examining air pollution and health in a national study population*, Atmospheric Environment 80 (2013) 161e171.
- [119] Tamás Fráter et al., *Unmanned Aerial Vehicles in Environmental Monitoring—An Efficient Way for Remote Sensing*, Journal of Environmental Science and Engineering A 4 (2015) 85–91.
- [120] Ozgur Kisi, Kulwinder Singh Parmar, Kirti Soni, Vahdettin Demir, *Modeling of air pollutants using least square support vector regression, multivariate adaptive regression spline, and M5 model tree models*, Air Quality, Atmosphere & Health September 2017, Volume 10, Issue 7, pp 873–883.
- [121] Arshia Chander et al., *A new eye in the sky: Eco-drones*, Environmental Development Volume 7, July 2013, Pages 155–164.
- [122] G. Di Stefano et al., *The Lusi drone: A multi-disciplinary tool to access extreme environments* Marine and Petroleum Geology 90 (2018) 26e37.
- [123] José I. Suárez et al., *Bluetooth Electronic Nose for Odour Monitoring and Control*, Chemical Engineering transactions, Vol. 68, 2018.
- [124] N. Castell et al., *Can commercial low-cost sensor platforms contribute to air quality monitoring and exposure estimates?*, Environment International 99 (2017) 293–302.
- [125] A. Moreno-Rangel et al., *Field evaluation of a low-cost indoor air quality monitor to quantify exposure to pollutants in residential environments*, Journal of Sensors Sensor Systems, 7, 373–388, 2018.
- [126] World Meteorological Organization (WMO), 2018, *Low-cost sensors for the measurement of atmospheric composition: overview of topic and future applications*, World Meteorological Organization (WMO).
- [127] Stanislaw Anweiler, Dawid Piwowarski, *Multi-copter platform prototype for environmental monitoring*, Journal of Cleaner Production Volume 155, Part 1, 1 July 2017, Pages 204–211.
- [128] Schwela, Dieter. 2012. *Review of urban air quality in Sub-Saharan Africa region - air quality profile of SSA countries (English)*. Washington, DC: World Bank.
- [129] Prashant Kumar et al., *The rise of low-cost sensing for managing air pollution in cities*, Environ. Int. 2015 Feb; 75, 199–205.
- [130] K. S. Adu-Manu et al., *Water Quality Monitoring Using Wireless Sensor Networks: Current Trends and Future Research Directions*, Trans. Sensor Netw. 00, 00, Article 000 (2016).
- [131] M. Pule et al., *Wireless sensor networks: A survey on monitoring water quality*, Journal of Applied Research and Technology 15 (2017) 562–570.
- [132] Christopher J. Paciorek and Yang Liu, *Assessment and Statistical Modeling of the Relationship Between Remotely Sensed Aerosol Optical Depth and PM_{2.5} in the Eastern United States*, 2012 HEI Research Report 167.
- [133] I. Maccà et al. (2008), *Occupational exposure to electromagnetic fields in physiotherapy departments*. Radiation protection dosimetry, 128 (2), 180–190.
- [134] Gryz K. Zradziński, P. & Karpowicz J. (2015), *The role of the location of personal exposimeters on the human body in their use for assessing exposure to the electromagnetic field in the radiofrequency range 98–2450 MHz and compliance analysis: evaluation by virtual measurements*. BioMed research international, 2015.
- [135] Shah S. G. S., & Farrow A. (2014), *Systematic literature review of adverse reproductive outcomes associated with physiotherapists' occupational exposures to non-ionising radiation*. Journal of occupational health, 56 (5), 323–331.
- [136] Karpowicz J. & Gryz K. (2013), *An assessment of hazards caused by electromagnetic interaction on humans present near short-wave physiotherapeutic devices of various types including hazards for users of electronic active implantable medical devices (AIMD)*. BioMed research international, 2013.
- [137] Gryz K. & Krapowicz J. (2014), *Environmental impact of the use of radiofrequency electromagnetic fields in physiotherapeutic treatment*. Roczniki Państwowego Zakładu Higieny, 65 (1).
- [138] C. Koutsojannis et al, *Microwave diathermy in physiotherapy: Introduction and evaluation of a quality control procedure*, Radiation Protection Dosimetry (2018), Vol. 181, No. 3, pp. 229–239.
- [139] Stacy Eltiti et al. (2007), *Does Short-Term Exposure to Mobile Phone Base Station Signals Increase Symptoms in Individuals Who Report Sensitivity to Electromagnetic Fields? A Double-Blind Randomized Provocation Study*, Environmental Health Perspectives, Vol. 115, No. 11.
- [140] Sabine J. Regel et al. (2006), *UMTS Base Station-like Exposure, Well-Being, and Cognitive Performance*, Environmental Health Perspectives, 114 (8): 1270–1275.
- [141] P. C. Huang et al., *Association between media coverage and prevalence of idiopathic environmental intolerance attributed to electromagnetic field in Taiwan*, Environmental Research 161 (2018) 329–335.
- [142] Aaron Reuben; Avshalom Caspi, Daniel W. Belsky, et al (2017), *Association of Childhood Blood Lead Levels With Cognitive Function and Socioeconomic Status at Age 38 Years and With IQ Change and Socioeconomic Mobility Between Childhood and Adulthood*, Jama Psychiatric 2017; 317 (12): 1244–1251.