J. Basic. Appl. Sci. Res., 2(12)12365-12372, 2012
© 2012, TextRoad Publication
ISSN 2090-4304
Journal of Basic and Applied Scientific Research
www.textroad.com

Air, Water, and Soil Pollution Study in Industrial Units Using Environmental Flow Diagram

Mohammad Valipour[1], Seyyed Morteza Mousavi[2], Reza Valipour[3], Ehsan Rezaei[4]

[1]Department of Irrigation and Drainage Engineering, College of Abureyhan, University of Tehran, Pakdasht, Tehran, Iran
[2]Department of Hydrocarbon Reservoirs Engineering, Faculty of Oil Engineering (FOE), Islamic Azad University, Science and Research Branch, Tehran, Iran
[3]Department of Chemical Process Engineering, College of Chemical Engineering, Islamic Azad University, Ahar Branch, Ahar, Iran
[4]Department of Thermo-Fluids Engineering, College of Mechanical Engineering, Amirkabir University of Technology, Tehran, Iran

ABSTRACT

Nowadays study of the industrial pollutions has become a controversial issue to reduce the risks of them in all of the world. Studding of air, water, and soil pollutions as separately may cause neglect from address to a comprehensive look in industrial pollution issue. In addition, without the exact information about quantity and quality of pollution sources, reduce or eliminate industrial pollutions are not possible. Environmental flow diagram (EFD) is made based on energy reference system (RES) and process flow diagram (PFD) for each industrial company or unit. In this paper, by coding in visual basic program environment, EFD designed for determining sources of pollutants, division sources of pollutants flows based on acceptor environment, and explaining impact of solutions to the energy optimization and reduce environmental pollutants. EFD is an user friendly software that can be used in all of the industrial companies particularly in Healthy, Safety, Environment (HSE) sections of operational units for detailed knowledge of pollution level of the area.

KEY WORDS: Air pollution, environmental flow diagram, HSE, reference energy system, soil pollution, water pollution.

INTRODUCTION

Pollution study in industrial units has been aimed at many researches, which some of them will be described in the following.

Li et al. (2000) studied on estimating unit loads of pollutants from industrial wastewater discharges. The results showed that all of the estimation models for the unit loads of pollutants have been generated for each industry, with 95% confidence levels for the validity test. Rathore (2012) studied on pollution load induced by dyeing and printing units in River Bandi at Pali, Rajasthan, India. Varis et al. (1990) used Bayesian influence diagram approach to complex environmental management including observational design. The approach appeared to be straightforward and practical in structuring and constructing models, in performing optimization, sensitivity tests and value of information analysis, and analyzing the management problem under different prevailing risk attitudes. The untreated or partially treated effluent on entering a water body either gets dissolved or lie suspended on river bed, thereby causing the pollution of water body (Panda et al., 2006). Varis and Kettunen (1988) presented DAVID influence diagram processing system in environmental management. The deterioration in water quality has an adverse on human beings as well as aquatic ecosystem directly or indirectly (Chinda et al., 2004, Ugochukwo, 2004, Emongor et al., 2005). Voigt et al. (2006) used the Hasse Diagram Technique (ProRank) software for a multi-criteria evaluation of environmental databases. The degradation of surface and groundwater quality due to industrial and urban waste has been recognized for a long time (Olayinka, 2004). Filibeli et al. (1996) controlled pollution in organized industrial districts in Turkey successfully. Ma (2010) analyzed the distribution of industrial pollution sources in U.S. and China. The study found that race and income-the two common lenses used in many U.S. studies played different roles in the Chinese context and rural residents and especially rural migrants were disproportionately exposed to industrial pollution. Kakar and Bhatnagar (1981) survived ground water pollution due to industrial effluents in Ludhiana, India. Oketola and Osibanjo (2007) estimated sectoral pollution load in Lagos by Industrial Pollution Projection System (IPPS). Magiera et al. (2007) used soil magnetometry for mapping particulate pollution loads in urban forests in the Upper Silesia Industrial Region, Poland. They said that very low soil pH usually favored the release of heavy metals and other toxic elements into the soil environment, and through the soil, directly into the forest ground flora and underground water system. Krishna et al. (2009) assessed heavy metal pollution in water using multivariate statistical techniques in an industrial area in India. This study indicated the necessity and

*Corresponding Author: Mohammad Valipour Department of Irrigation and Drainage Engineering, College of Abureyhan, University of Tehran, Pakdasht, Tehran, Iran, Email:vali-pour@hotmail.com

usefulness of multivariate statistical techniques for evaluation and interpretation of the data with a view to get better information about the water quality and design some remedial techniques to prevent the pollution caused by hazardous toxic elements in future. Chakrabarti and Mitra (2005) researched Economic and environmental impacts of pollution control regulation on small industries. Zhao et al. (2009) presented a plant-level aggregation method for the case of a small region in China to regional industrial production's spatial distribution and water pollution control. The pollution control strategy's effect indicated a large different level of spatial equity for industry and government respectively. Banerjee et al. (2011) showed application of air pollution dispersion modeling for source-contribution assessment and model performance evaluation at integrated industrial estate-Pantnagar. Allen and Rosselot (1994) studied pollution prevention at the macro scale. Pen-Mouratov et al. (2010) introduced soil free-living nematodes as indicators of both industrial pollution and livestock activity in Central Asia. This study confirmed that the grazing in accompaniment to industrial pollution, intensify a negative effect on soil nematode communities. Pearce and Kingham (2008) studied environmental inequalities in New Zealand. Romano et al. (2008) presented benthic foraminifera as a tool in integrated programs of environmental characterization. He (2006) studied about pollution haven hypothesis and environmental impacts of foreign direct investment. Ramzan et al. (2008) evaluated and improved environmental performance of HC's recovery system. Sivacoumar et al. (2001) discussed air pollution modeling for an industrial complex and model performance evaluation. The model performance was found good with an accuracy of about 68%. Nelson-Smith (1971) researched the problem of oil pollution of the sea. Shefer (1973) forecasted industrial air pollution in the Haifa bay area with an input-output model. Ntengwe (2005) reviewed industrial wastewater treatment and analysis as means of preventing pollution of surface and underground water bodies in Zambia.

In all previous researches, binding pollution sources (air, water, and soil) have been studied as separately, but these three sources are inseparable. In addition, in previous studies only the ways to deal with industrial pollution have been investigated. However without the exact information about quantity and quality of pollution sources, reduce or eliminate industrial pollutions are not possible. In this article, using environmental flow diagram pollutants of industrial units were identified and decisions about environmental pollution were as simple as possible.

MATERIALS AND METHODS

Environmental flow diagram was designed based on the reference energy system. The difference was that the units that have not been considered in terms of environmental, have been removed and units that were not in the process, but in terms of environmental concern have been added to it. RES indicates all energy levels include extraction, collection, primary and final processing, separation, conversion, storage, transmission, distribution, loading, and end-users of energy carriers. In RES diagram, each line shows energy flow but EFD uses to detect and identify sources of pollutant and each line shows pollutant flow. In this diagram, all the units are in the specified energy levels and pollutants flow are enumerated according to the environmental source (air, water, soil) of pollution acceptor. In this diagram, the source of production, transmission and conversion processes, and the recipient environmental sources of these pollutants are specified. Generally, the guideline of EFD preparation includes the following steps:

1. Investigating all of the energy levels in RES and PFD of processing units to identify sources of pollutant
2. Pollutant flows division based on pollution acceptor source (water, air, and soil)
3. Determining a level for produced pollution as the final pollution in the end of diagram and divides it based on pollution acceptor source
4. Removal of non-related terms to environmental pollutions
5. Adding other sources of pollution which non-related to energy levels such as industrial wastewater

Indicators of pollution that are examined in EFD includes greenhouse gases (CO_2, CH_4, and N_2O) and air pollutants (CO, SO_2, NO_x, and THC) in atmosphere section and BOD, COD, heavy metals, oil & grease, and total hardness in water and soil sections.

Methods of air pollution estimation in EFD include sampling of emission sources, emission factors available in international resources, engineering calculations, and process simulation. In addition, mode of evaluating water and wastewater in EFD include sampling of industrial wastewater in operational area, comparison with national and international standards, and detecting pollutants that are above environmental standards. All of the necessary states to designing of EFD have been done in visual basic program environment.

RESULTS AND DISCUSSION

Environmental flow diagram is user friendly software that can be used in all of the industrial companies particularly in Healthy, Safety, Environment (HSE) sections of industrial units.

By holding the mouse cursor over any of the icons in EFD, the full name of icon will display. By clicking on the label of each of the pollutant lines, the input and output lines depend on that label are marked. Figure 1 shows a sample of EFD for a part of National Iranian Oil Company (NIOC).

Icons that environmental information is available for them have been highlighted and by clicking on each of them amount and type of pollutants is determined. By clicking on the tables, the user enters into the Excel and can be change the data. User can only enter data, graphs and out of the standard range points is determined by the software. In air pollutants section, two separate scenarios are defined that characteristics of each one is visible. Also in the final section of air, soil, and water pollution, a comparison between different scenarios and the main points of pollutant has been done. In this section not need to enter data and due to the files are as link, graphs are drawn by EFD software. Figure 2 shows the final pollution in water section with suggested strategies for reducing or removing pollution problems in this section. In Figure 2, for example, maximum of pollution amount is for TDS in burn pit unit (2110 mg/l) and number of 14 strategies has been suggested for water pollution problems in this part.

Also on the "Options" menu, by clicking on the "Pollutant Point(s)" a window for determining year will be displayed. If selecting desired year, EFD software starts to calculate all of the pollution points and after end of the calculations, shows these points as red color. Thus, all points that amount of pollution in them excess of the environmental standards are specified. Figure 3 shows pollutant points for a part of National Iranian Oil Company (NIOC). In Figure 3, for example, water of the brine well (EX1) due to the red color of this icon is not drinkable but due to the after pollution calculations the color of water treatment complex (WTC) is not red, water of the brine well is suitable for drink after treating in WTC. As other example in Figure 3, red color of septic tank 1 (S 1) and yard farming (YF) icons shows that output of septic tank 1 is not appropriate for landscape irrigation.

Conclusion

In this study, by coding in visual basic program environment, EFD designed for determining sources of pollutants, division sources of pollutants flows based on acceptor environment, and explaining impact of solutions to the energy optimization and reduce environmental pollutants. EFD is an user friendly software that can be used in all of the industrial companies particularly in Healthy, Safety, Environment (HSE) sections of operational units for detailed knowledge of pollution level of the area.

REFERENCES

Allen D. T. and K. S. Rosselot, 1994. Pollution prevention at the macro scale: flows of wastes, industrial ecology and life cycle analyses, Waste Management, 14 (3-4), pp. 317–328. doi: http://dx.doi.org/10.1016/0956-053X(94)90078-7

Banerjee T., S. C. Barman and R. K. Srivastava, 2011. Application of air pollution dispersion modeling for source-contribution assessment and model performance evaluation at integrated industrial estate-Pantnagar, Environmental Pollution, 159 (4), pp. 865–875. doi: http://dx.doi.org/10.1016/j.envpol.2010.12.026

Chakrabarti S., and N. Mitra, 2005. Economic and environmental impacts of pollution control regulation on small industries: a case study, Ecological Economics, 54 (1), pp. 53–66. doi: http://dx.doi.org/10.1016/j.ecolecon.2004.09.019

Chinda A. C., A.S. Braide and O. C. Sibeudu, 2004. Distribution of hydrocarbons and heavy metals in sediments and a crustacean (shrimps-Penaeus notialis) from the bonny/new calabar estuary Nigeria delta, Ajeam-Ragee, 9, pp. 1-14.

Emongor V., E. Kealotswe, I. Kooprapetse, S. Sankwasa and S. Keikanestswe, 2005. Pollution indicators in Gaberone effluent, Journal of Applied Science, 5, pp. 147-150.

Filibeli A., F. Sengül and A. Müezzinoglu, 1996. Control of pollution in organized industrial districts: A case study from Turkey, Water Science and Technology, 34 (12), pp. 127–133. doi: http://dx.doi.org/10.1016/S0273-1223(96)00861-X

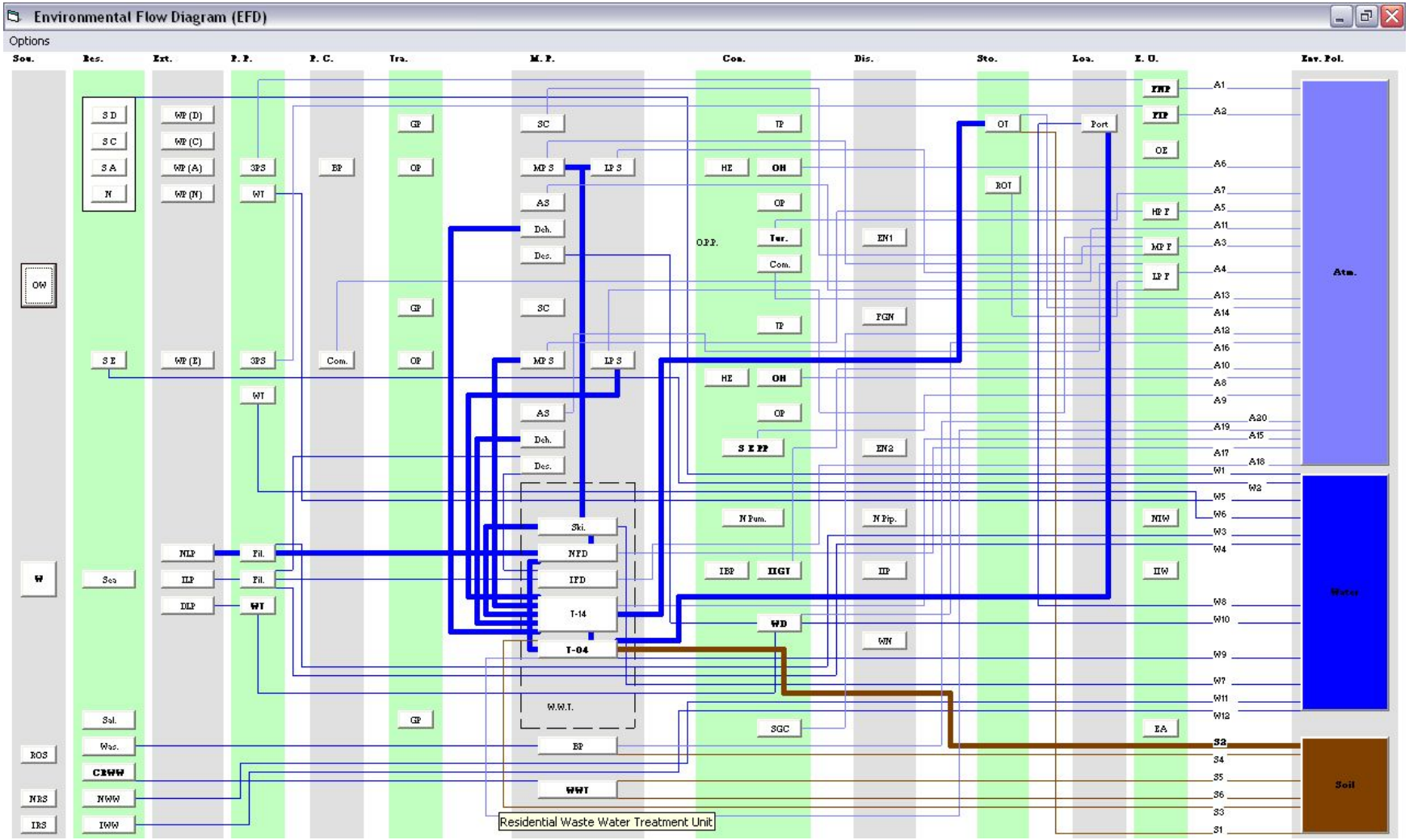
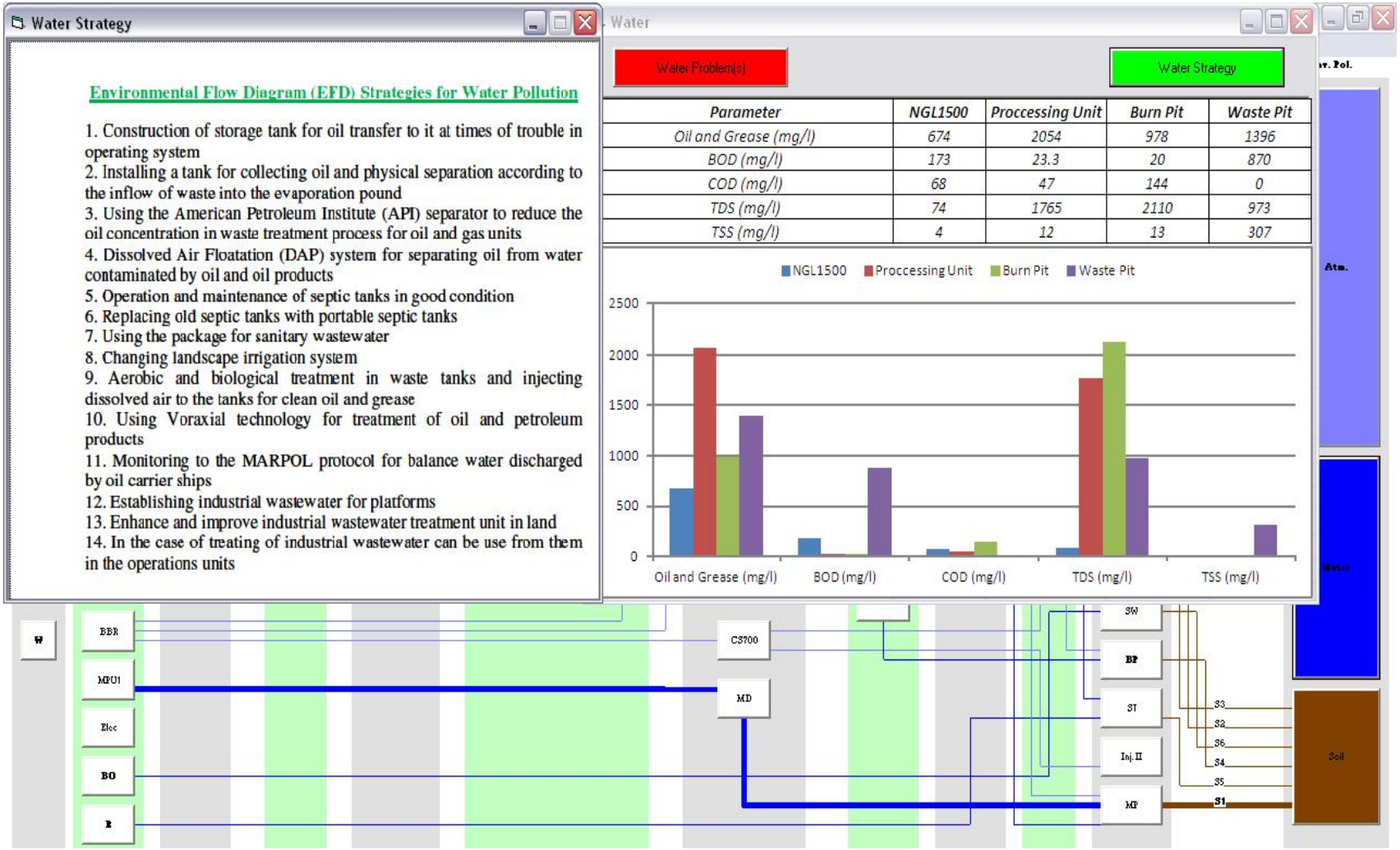


Fig. 1- A sample of EFD for a part of NIOC



Parameter	NGL1500	Proccessing Unit	Burn Pit	Waste Pit
Oil and Grease (mg/l)	674	2054	978	1396
BOD (mg/l)	173	23.3	20	870
COD (mg/l)	68	47	144	0
TDS (mg/l)	74	1765	2110	973
TSS (mg/l)	4	12	13	307

Fig. 2- Final pollution in water section with suggested strategies for reducing or removing pollution problems in this section

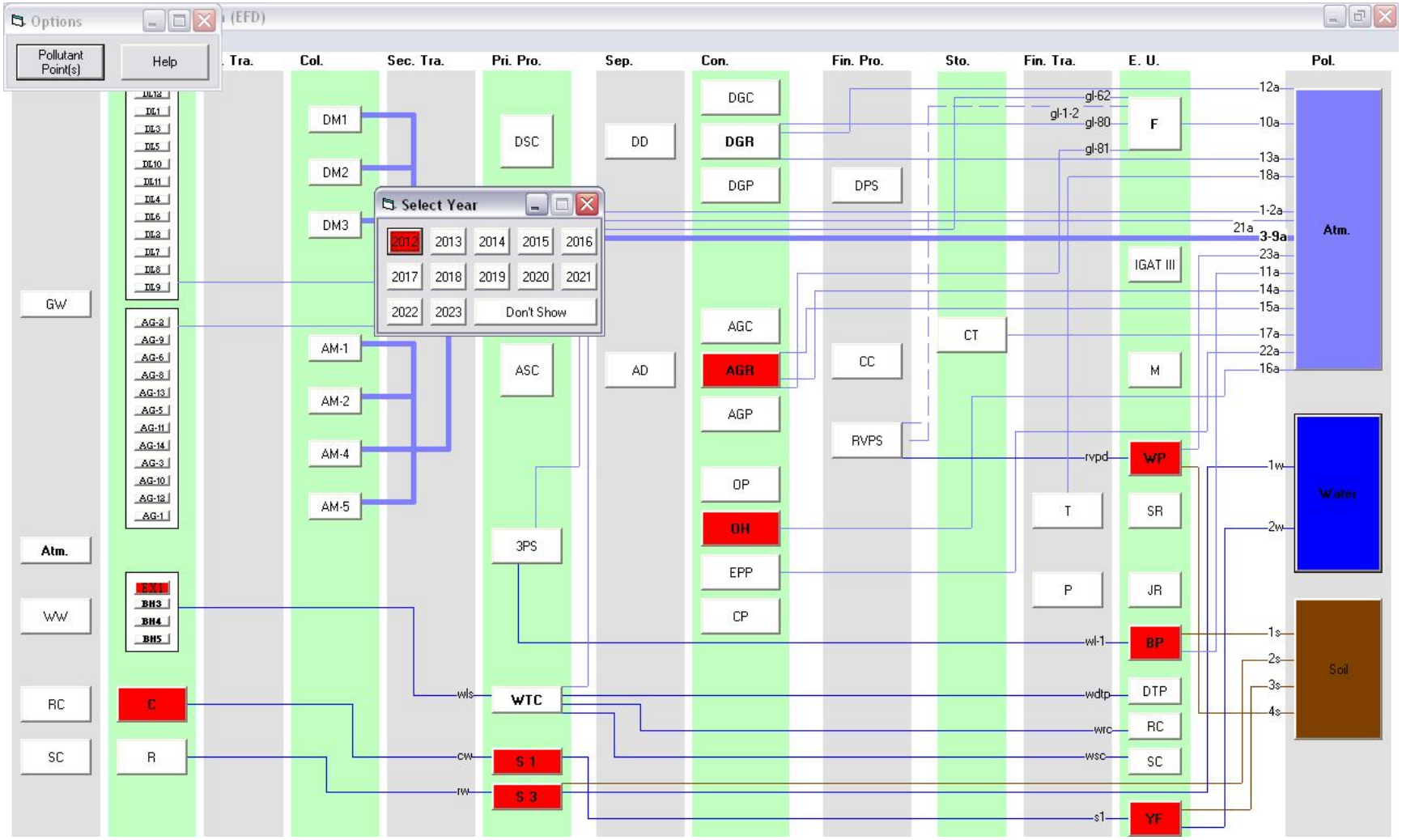


Fig. 3- Pollutant points for a part of NIOC

He J., 2006. Pollution haven hypothesis and environmental impacts of foreign direct investment: The case of industrial emission of sulfur dioxide (SO2) in Chinese provinces, Ecological Economics, 60 (1), pp. 228–245. doi: http://dx.doi.org/10.1016/j.ecolecon.2005.12.008

Kakar Y. P. and N. C. Bhatnagar, 1981. Ground Water Pollution Due to Industrial Effluents in Ludhiana, India, Studies in Environmental Science, 17, pp. 265–272. doi: http://dx.doi.org/10.1016/S0166-1116(08)71914-9

Krishna A. K., M. Satyanarayanan and P. K. Govil, 2009. Assessment of heavy metal pollution in water using multivariate statistical techniques in an industrial area: A case study from Patancheru, Medak District, Andhra Pradesh, India, Journal of Hazardous Materials, 167 (1-3), pp. 366–373. doi: http://dx.doi.org/10.1016/j.jhazmat.2008.12.131

Li K. C., Y. J. Tseng, C. C. Fu and S. T. Hu, 2000. STUDY ON ESTIMATING UNIT LOADS OF POLLUTANTS FROM INDUSTRIAL WASTEWATER DISCHARGES, Journal of the Chinese Institute of Environmental Engineering, 10 (3), pp. 241-248.

Ma C., 2010. Who bears the environmental burden in China—An analysis of the distribution of industrial pollution sources?, Ecological Economics, 69 (9), pp. 1869–1876. doi: http://dx.doi.org/10.1016/j.ecolecon.2010.05.005

Magiera T., Z. Strzyszcz and M. Rachwal, 2007. Mapping particulate pollution loads using soil magnetometry in urban forests in the Upper Silesia Industrial Region, Poland, Forest Ecology and Management, 248 (1-2), pp. 36–42. doi: http://dx.doi.org/10.1016/j.foreco.2007.02.034

Nelson-Smith A., 1971. The Problem of Oil Pollution of the Sea, Advances in Marine Biology, 8, pp. 215–306. doi: http://dx.doi.org/10.1016/S0065-2881(08)60493-9

Ntengwe F.W., 2005. An overview of industrial wastewater treatment and analysis as means of preventing pollution of surface and underground water bodies—the case of Nkana Mine in Zambia, Physics and Chemistry of the Earth, Parts A/B/C, 30 (11-16), pp. 726–734. doi: http://dx.doi.org/10.1016/j.pce.2005.08.014

Oketola A. A. and O. Osibanjo, 2007. Estimating sectoral pollution load in Lagos by Industrial Pollution Projection System (IPPS), Science of The Total Environment, 377 (2-3), pp. 125–141. doi: http://dx.doi.org/10.1016/j.scitotenv.2006.12.054,

Olayinka K. O., 2004. Studies on industrial pollution in Nigeria: The effect of textile effluents on the quality of groundwater in some parts of Lagos, Nigerian Journal of Health and Biomedical Sciences, 3, pp. 44-50.

Panda U. C., S. K. Sundaray, P. Rath, B. B. Nayak and D. Bhatta, 2006. Application of factor and cluster analysis for characterization of river and estuarine water system- A case study: Mahanadi River (India), Journal of Hydrology, 331(3-4), pp. 434-445.

Pearce J. and S. Kingham, 2008. Environmental inequalities in New Zealand: A national study of air pollution and environmental justice, Geoforum, 39 (2). pp. 980–993. doi: http://dx.doi.org/10.1016/j.geoforum.2007.10.007

Pen-Mouratov S., N. Shukurov and Y. Steinberger, 2010. Soil free-living nematodes as indicators of both industrial pollution and livestock activity in Central Asia, Ecological Indicators, 10 (5), pp. 955–967. doi: http://dx.doi.org/10.1016/j.ecolind.2010.02.005

Ramzan N., S. Degenkolbe and W. Witt, 2008. Evaluating and improving environmental performance of HC's recovery system: A case study of distillation unit, Chemical Engineering Journal, 140 (1-3), pp. 201–213. doi: http://dx.doi.org/10.1016/j.cej.2007.09.042

Rathore J., 2012. Studies on pollution load induced by dyeing and printing units in River Bandi at Pali, Rajasthan, India, INTERNATIONAL JOURNAL OF ENVIRONMENTAL SCIENCES, 3 (1), ISSN 0976 – 4402, pp. 735-742.

Romano E., L. Bergamin, M. G. Finoia, M. G. Carboni, A. Ausili and M. Gabellini, 2008. Industrial pollution at Bagnoli (Naples, Italy): Benthic foraminifera as a tool in integrated programs of environmental characterization, Marine Pollution Bulletin, 56 (3), pp. 439–457. doi: http://dx.doi.org/10.1016/j.marpolbul.2007.11.003

Shefer D., 1973. Forecasting industrial air pollution in the Haifa bay area with an input-output model, Socio-Economic Planning Sciences, 7 (5), pp. 397–406. doi: http://dx.doi.org/10.1016/0038-0121(73)90038-4

Sivacoumar R., A. D. Bhanarkar, S. K. Goyal, S. K. Gadkari and A .L. Aggarwal, 2001. Air pollution modeling for an industrial complex and model performance evaluation, Environmental Pollution, 111 (3), pp. 471–477. doi: http://dx.doi.org/10.1016/S0269-7491(00)00083-X

Ugochukwu C. N. S., 2004. Effluent monitoring of oil servicing company and its impact on the environment, Ajeam-Ragee, 8, pp. 27-30.

Varis O., J. Kettunen, H. Sirviö, 1990. Bayesian influence diagram approach to complex environmental management including observational design, Computational Statistics & Data Analysis, 9 (1), pp. 77–91. doi: http://dx.doi.org/10.1016/0167-9473(90)90072-P

Varis O., J. Kettunen, 1988, DAVID influence diagram processing system in environmental management, Environmental Software, 3 (2), pp. 81–84. doi: http://dx.doi.org/10.1016/0266-9838(88)90014-7

Voigt K., R. Brüggemann and S. Pudenz, 2006. A multi-criteria evaluation of environmental databases using the Hasse Diagram Technique (ProRank) software, Environmental Modelling & Software, 21 (11), pp. 1587–1597. doi: http://dx.doi.org/10.1016/j.envsoft.2006.05.005,

Zhao N., Y. Liu and J. Chen, 2009. Regional industrial production's spatial distribution and water pollution control: A plant-level aggregation method for the case of a small region in China, Science of The Total Environment, 407 (17), pp. 4946–4953. doi: http://dx.doi.org/10.1016/j.scitotenv.2009.05.023