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FUZZY MODEL OF AIR DUST CONCENTRATION IN KYIV FOR PM2.5 AND PM10

Abstract. Authors presents the fuzzy model of air dust concentration. The dust model allows the application of algorithms and methods of artificial intelligence. The authors have made a brief overview of simulation of dust emission in different countries and regions. Previously, fuzzy logic models were not enough use in these studies. However, these models are widely used in medicine. The authors hope that their modest contribution to fuzzy modelling of environmental problems will attract the attention of other researchers. In this work, we used the results of measurements that carried out at the meteorological stations in Kyiv. The authors' fuzzy model makes it possible to simulation into account two channels for measuring dust: PM2.5 and PM10.

It was found that in the Mamdani algorithm it is necessary to apply the "or" logic. This makes it possible to increase the influence of each channel on the negative assessment of the environment. The Mamdani algorithm in the "and" logic does not give strict restrictions on the concentration of dust in the atmospheric air for each of the measuring channels (PM2.5 and PM10) separately.

Keywords: dust emissions, particulate matter, PM10, PM2,5, fuzzy logic, Mamdani algorithm, AQI.

INTRODUCTION

Particulate matter (PM) is small airborne particles. Some particulate matter is natural and some is man- made. In general, the smaller the particle the deeper it can be inhaled into the lung. A type of gravimetric sampler used for measuring ambient concentrations of PM10 or PM2.5.

PM10. Particles which pass through a size-selective inlet with a 50 % efficiency cut-off at 10 micrometers aerodynamic diameter, as defined in ISO 7708:1995, Clause 6[1].

PM2.5. Particles which pass through a size-selective inlet with a 50 % efficiency cut-off at 2.5 micrometers aerodynamic diameter, as defined in ISO 7708:1995, Clause 7.1 [1].

Dust emission modelling for different countries and regions is currently in many works. Modeling of dust emissions (PM10 and PM2,5) in Mediterranean region is executions in [2-3]. Experimental research of dust deposition in Iran published in [4].

In Poland researched dust emission (PM2,5) in atmospheric air in urban agglomeration of Lublin [5].

More than two hundred meteorological stations monitor the Kyiv air (among other things, they measure the concentration of PM2.5 and PM10 dust) in real time [6]. The objective of this study is to apply fuzzy logic [7] to the air quality model in Kyiv (for dustiness PM2.5 and PM10). Fuzzy models are widely used today various expert systems.

APPROUCHES AND METHODOLOGY

For numerical gradation when monitoring the air, a special technique is used. The Air Quality Index (AQI) is used by government agencies to inform the public how polluted the air is at present or how polluted to become. Public health risks increase as the AQI rises. The air quality index includes, among other components, the PM2.5 dust concentration. The total dust in the air (PM2.5 and PM10) does not have a separate

index. AQI is the sum of several relative concentrations of principal substances of the same weight. The AQI calculated as a point scale.

The authors propose to apply fuzzy modeling to take into account two dust factors: PM2.5 and PM10. Input data for the model were from monitoring stations in Kyiv. The calculations were in the MATLAB program (fuzzy logic module).

RESULTS OF FUZZY MODELLING

In the city of Kyiv, there are currently 328 stations of air monitoring, of which 122 are November 2021, 18, in operation. Monitoring stations were installed by: “SaveDnipro”, “luftdaten.info”, “Eco City”, “AirVisual”, “AirPol”, “Kyiv Smart City”, “LUN Misto”, “Taras Shevchenko National University of Kyiv”, “Ukrainian Hydrometeorological Center”, “European radiological data exchange system”, “Kyiv City State Administration”, “Airly”, “PurpleAir”.

Stations in the Shulyavka area on a fragment of the Kyiv map with colored circles. The numbers in circles represent AQI [Fig. 1].

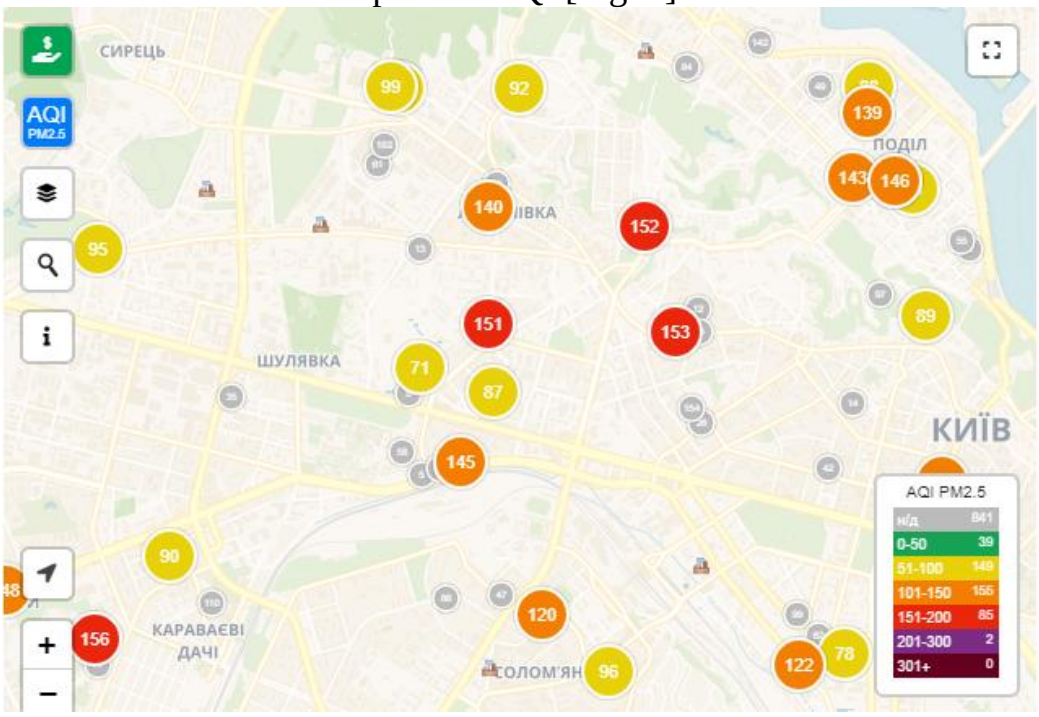

Figure 1. – Mape of Shulyavka area: AQI represent November 2021, 18, 21-00

Results of AQI, dust concentration measurements (in micrograms in cubic meter) and fuzzy modeling (“AirDust” in scale [0; 100] balls) presents in Table 1.

Table 1. Air quality in stations of Shulyavka area, November 2021, 18, 21-00

№	Address of station	Operator	AQI	PM2.5	PM10	AirDust
1	Borshchahivska, 13	LUN Misto	145	57,4	78,3	52
2	Kyrylo-Mefodijivska, 3	Luftdaten.info	87	38,7	68,6	55
3	Mytrofana Dovnar-Zapolskoho, 3	LUN Misto	151	67,6	85,5	59,4
4	Tbilisky provulok, 4	Luftdaten.info	71	32,2	100,6	59,3

The authors have developed two fuzzy models for air dust content. One of the models has inference rules in the AND logic, the other – in the OR logic.

The following parameters were set in the simulations:

- model type – Mamdani;
- the number of inputs is two: “InputPM2.5” and “InputPM10”;
- the number of output is one (“AirDust”);
- the type of input membership functions is Gaussian (“PM2.5green”, “PM2.5yellow” and “PM2.5red”; “PM10green”, “PM10yellow” and “PM10red”);
- the type of output membership functions is triangular (“DustGreen”, “DustYellow” and “DustRed”);
- the range of first input is 0-75 microgram in cubic meter;
- the range of second input is 0-300 microgram in cubic meter;
- the range of output is 0-100 balls.

The surface of modeling present in Fig. 2 and calculation results – in Fig. 3.

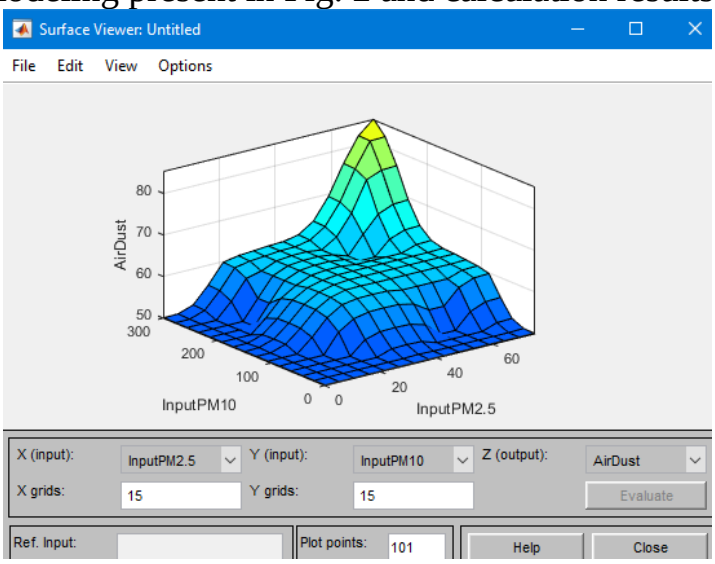

Figure 2 – Surface viewer of air dustiness for rules logic type OR

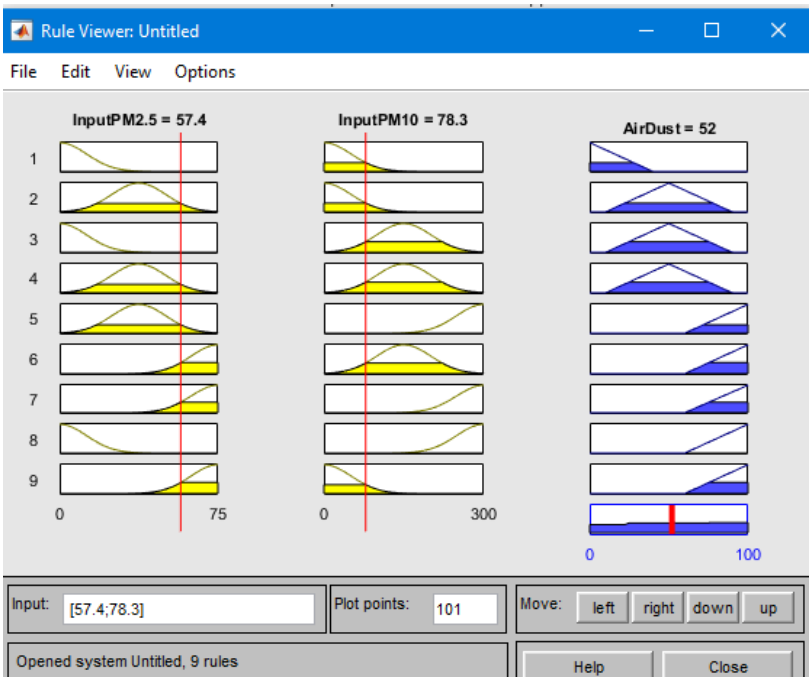

Figure 3 – Calculation of “AirDust” in fuzzy logic mode: logic type is OR

The integral indicator of dust content AD ("Air Dust") can differ significantly from the AQI (Air Quality Index) – see columns "AQI" and "AirDust" in table 1. This fact by the presence of sources other than dust (only PM2.5) in the AQI definition.

The dust scale takes into account the maximum dust concentration. With an adaptive scale, we get more differences in the dust assessment.

CONCLUSIONS

In a fuzzy model, the authors proposed an integral indicator ("AirDust" – AD) of air dust content by two types of particles simultaneously – PM2.5 and PM10.

It was found that in the Mamdani algorithm it is necessary to apply the "or" logic. This makes it possible to increase the influence of each channel on the negative assessment of the environment. The Mamdani algorithm in the "and" logic does not give strict restrictions on the concentration of dust in the atmospheric air for each of the measuring channels (PM2.5 and PM10) separately.

The fuzzy model tested on input data from four meteorological stations in Kyiv in real time mode. Localization of sources – Shulyavka area.

These studies can continued to refine the dust content scale in fuzzy model (nonlinear scale, extending rules, third input function, adaptive range for dust concentration PM2.5 and PM10, etc.).

This fuzzy logic model also allows you to get a relative rating of air dust concentration for each localization.

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