MULTI-CRITERIAL ANALYSIS OF ENVIRONMENTAL ACCIDENTAL POLLUTION EVENTS IN ROMANIA BETWEEN 2019-2021

Răzvan BĂTINAŞ[1], Melania CORLECIUC[2], Irina-Liliana IONIȚĂ[2]
Bogdan-Gabriel PITICARI [3], Simion NACU[4]

ABSTRACT. – Multi-criterial analysis of accidental pollution events in Romania between 2019-2021. The study is focused on the assessment of so-called "environment incidents" using the database generated through National Environmental Protection Agency. The result will emphasize the typology of the events by the nature of the affected environmental factor (air, water, soil), the spatial distribution on counties and regional level and also temporal occurrence. Most events are associated with water environment, followed by those affecting the soil and the air. Using the pollutant nature evaluation, we have noticed that the most common substances/process responsible for affecting the environmental factors were: hydrocarbons, fires with different origin and involved materials and wastewaters evacuations.

Keywords: accidental pollution events, temporal frequency, vulnerability.

1. INTRODUCTION

Accidental pollution is a major environmental event that occurs in all its structures and for very complex reasons. Their scientific analysis involves a classification according to the polluted environment, the polluting agent, the causes of the phenomenon and its consequences to human or wildlife habitats. In all cases, the effects of these environmental accidents are important from a social, ecological and economical point of view. Equally important, are the concerns of society, and especially of the environmental specialists, for their prevention and for the immediate interventions in order to reduce and eliminate the damages produced. The alarming increase number of accidental pollution, and especially of those with serious

[1] Babeş-Bolyai University, Cluj-Napoca, Romania e-mail: razvan.batinas@ubbcluj.ro
[2] National Environmental Protection Agency, Bucharest, Romania, e-mail: melania.corleciuc@anpm.ro irina.ionita@anpm.ro
[3] N.A. Romanian Waters, S.G.A. Suceava, Romania,e-mail: bogdan.piticari@sgasv.das.rowater.ro
[4] N.A. Romanian Waters, Bucharest, Romania, e-mail: simion.nacu@rowater.ro

consequences, requires urgent measures to update and increase control activities both through direct systematic actions and through better cooperation between territorial environmental authorities and potentially polluting economic agents.

Accidental pollution events can be caused by technological and human negligence, pollution of localities and lands with oil or chemical products, by breaking the transport pipes of these products, pollution due to traffic accidents and pollution caused by natural factors.

Romanian network responsible for monitoring potential accidental pollution events is coordinated by the Ministry of the Environment, through a wide spread centers located in every county, with special departments that are focused on these types of events. The basic legislation for evaluation/monitoring and specific interventions to diminish the effects of pollution events are presented in Environmental Protection Law no. 137 from 1995 and in Ministerial Order 2579 from 2012. The main authority on the national level is The National Environmental Protection Agency (NEPA) with is territorial county smaller agencies who are collecting the information regarding these events.

Most common sources for air pollution are affecting human health and in continuous and prolonged conditions can lead to death (Gulland, 2014). In Romania, most affected areas are overlapping urban habitats and are generated by traffic and industrial activities found in the proximity of cities and towns (Iorga, 2022). In the last years, many scientific papers were focused on the air quality in major Romanian cities Bucharest (Bodor et all, 2020), Iași (Sfîcă et all, 2018), Brașov (Năstase et all, 2018), Cluj-Napoca (Soporan et all, 2015).

The state of quality of water resources is conditioned both by the way they are used as sources of water supply by the population, industry and other uses, and by the use of resources as receivers of wastewater discharged after use. One of the important measures for maintaining the quality of water resources is the activity of preventing and combating accidental pollution. In Romania the subject of accidental pollution events affecting water network was documented in many studies focused either on single events: Baia Mare cyanide incident (Schwabach, 2000), mining spots from Apuseni Mountains (Bird, 2009), small watersheds: Arieș basin (Bătinaș, 2003), large watersheds: Siret basin (Zait et all, 2021) or at country level (Galatchi, 2006) and (Breabăn, 2020).

2. DATA AND METHODS

The raw data provided by the NEPA is expanded over three years (2019 - 2021) and contains information regarding the locality affected, county name, the environmental factor involved in the pollution event, the type of pollutant and the water stream name (where there is a water pollution event). Data was collected by the local county agencies and then processed at NEPA. In order to obtain the spatial distribution, we have used MS Excel and ArcGIS map software. Also, we have identified the most vulnerable seasons/months and locations towards accidental environmental pollution events.

155

3. RESULTS

In the last three years (2019 - 2021), Romania has experienced and registered 494 accidental pollution events. Considering each year from the analyzed period, we have noticed a slightly growing tendency (2019 – 156 events, 2020 – 168 events and 2021 – 170 recorded events).

The raw data has emphasized that by the environmental factor affected were detected six distinct items: air, water, soil (as individual target) and air – soil, water – soil, air – water – soil (as multiple target). The complete results are available in table below (table 1). The most targeted environmental factor was water (157 events), followed by air (150) and soil (146).

Table 1. *Records of accidental pollution based on affected environmental factor*

No	Affected environmental factor	2019	2020	2021	Total
1	Air	45	43	62	**150**
2	Water	52	59	46	**157**
3	Soil	49	52	45	**146**
4	Air - soil	4	10	6	**20**
5	Water - soil	6	4	10	**20**
6	Air – water - soil	0	0	1	**1**
7	**Total events**	**156**	**168**	**170**	

Following the trend evolution for each environmental factor affected, we have noticed a significant increase for events associated to air/atmosphere (from 45 cases in 2019 to 62 cases in 2021). The other environmental factors (water and soil) have a relative steady evolution with around 50 events/year. If the accidental pollution was targeting two or even three environmental factors, the analysis has revealed low values.

The nature or type of pollutants was the next criteria used to appreciate what are the most involved substances or process that have triggered the pollution.

The main pollution sources are: wastewaters (with domestic and industrial genesis); runoff (agriculture and stormwater); bathing, cloth washing, etc., which is discharged into water bodies (Breabăn, 2020).

Organic pollutants, nitrogen and phosphorus-based compounds, heavy metals from mine drainage, untreated wastewaters from households, residual effluents with different origin are in general, the most common substances responsible for water pollution.

Analyzing the pollutant type or its nature, the recordings have shown a variety of incidents involving 29 different substances or processes (table 2). The most involved pollutants were hydrocarbons/oil compounds (214 events), fires (123) and wastewaters evacuation (82). They are responsible for around 90% of the total recorded events.

Table 2. *Pollutant nature/type involved in accidental pollution events (2019-2021)*

No	Pollutant nature / type	2019	2020	2021	No	Pollutant nature / type	2019	2020	2021
1	Ammoniacal waters	0	0	1	16	Landfill fire	0	1	0
2	Ammonium nitrate	0	1	0	17	Mine waters	2	0	3
3	Animal waste	0	0	1	18	Organic compounds	0	1	0
4	Bitumen	0	1	0	19	Other causes	2	1	1
5	Chemical fertilizer	1	1	0	20	Pyrite ash	0	0	1
6	Chemical waste	1	0	0	21	Quick lime	0	0	1
7	Chlorohydric acid	1	0	1	22	Slag	1	0	0
8	Diluent	0	1	0	23	Smoke	0	3	0
9	Fire	39	33	52	24	Sulphury acid	0	1	0
10	Fire, nitrogen oxides	1	2	0	25	Suspension particles	2	0	1
11	Gases	0	1	0	26	Unidentified	0	0	1
12	Household waters	0	14	2	27	Unknown	3	7	1
13	Hydrocarbons	71	66	77	28	Vegetation fire	0	4	0
14	Hydrocarbons, fire	1	3	2	29	Wastewaters	31	26	25
15	Klingerite dust	0	1	0	30	**Total events**	**156**	**168**	**170**

Geographical approach was made by using the development regions, counties and territorial units. In order to obtain a harmonic politics of territorial development compared to those created in the European Union and financial support for the territorial profile development, Romania has created eight development regions, each one containing several counties (Surd et all, 2011).

Table 3. *Events of accidental pollution recorded by development regions (2019-2021)*

Region name / year	2019	2020	2021	Total events by region
North-East	20	22	19	**61**
South-East	39	31	30	**100**
South - Muntenia	39	61	49	**149**
South-West Oltenia	5	4	3	**12**
West	4	3	24	**31**
North-West	6	7	9	**22**
Center	37	25	31	**93**
București - Ilfov	6	15	5	**26**
Total events by year	**156**	**168**	**170**	

The analysis has shown that the most events are recorded in the eastern half of the country, with largest value associated with the development region South – Muntenia (149 events), followed by South-East region (100 events) and Center development region (93 events) as presented in table 3.

Table 4. *Events of accidental pollution recorded by counties (2019-2021)*

No	County name	2019	2020	2021	No	County name	2019	2020	2021
1	Alba	6	1	9	22	Harghita	11	4	1
2	Arad	0	0	4	23	Hunedoara	2	0	2
3	Argeș	8	12	13	24	Ialomița	7	9	0
4	Bacău	8	4	2	25	Iași	6	8	9
5	Bihor	5	6	3	26	Ilfov	5	9	4
6	Bistrița Năsăud	1	1	0	27	Maramureș	0	0	1
7	Botoșani	1	1	0	28	Mehedinți	1	1	2
8	Brăila	7	1	2	29	Mureș	9	16	18
9	Brașov	7	4	3	30	Neamț	0	0	1
10	București	1	6	1	31	Olt	2	1	0
11	Buzău	4	4	3	32	Prahova	14	29	19
12	Călărași	0	0	4	33	Sălaj	0	0	2
13	Caraș-Severin	1	0	0	34	Satu Mare	0	0	2
14	Cluj	0	0	1	35	Sibiu	1	0	0
15	Constanța	24	24	21	36	Suceava	5	7	5
16	Covasna	3	0	0	37	Teleorman	2	5	6
17	Dâmbovița	4	6	3	38	Timiș	1	3	18
18	Dolj	1	1	0	39	Tulcea	2	0	1
19	Galați	2	2	2	40	Vâlcea	1	0	0
20	Giurgiu	4	0	4	41	Vaslui	0	2	2
21	Gorj	0	1	1	42	Vrancea	0	0	1

The spatial distribution has shown a very specific configuration based on counties analysis (table 4).
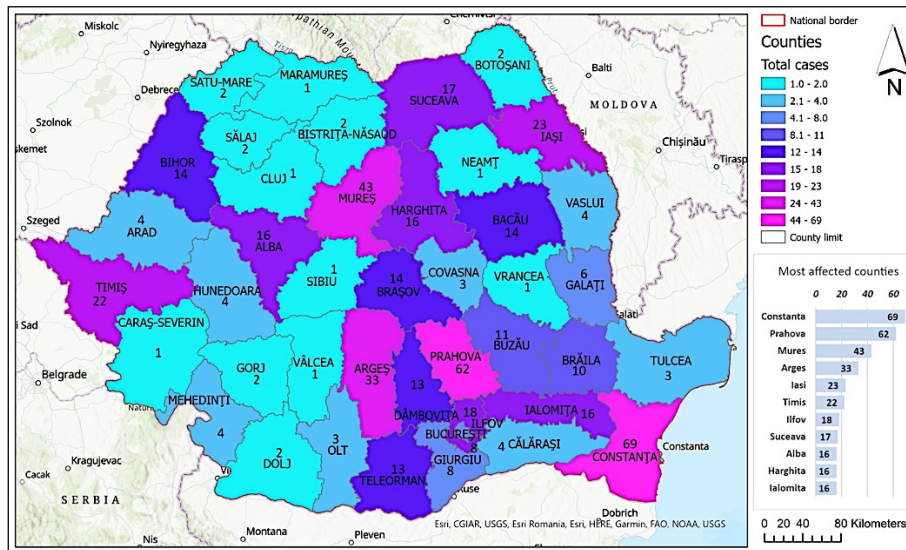
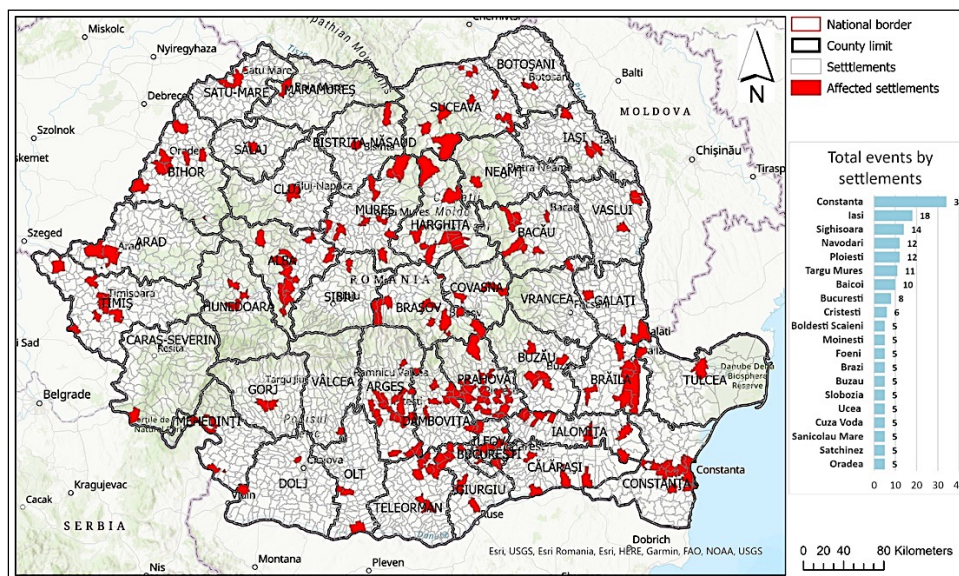**Fig. 1.** *Total accidental pollution events by counties in Romania (2019-2021)*

158

Due to the presence of many oils' refineries or oil terminal and port associated facilities most affected counties in Romania were Constanța (69 events) and Prahova (62 events). An important number of counties have recorded a single event for the three analyzed years: Caraș-Severin, Cluj, Maramureș, Neamț, Sibiu, Vâlcea, Vrancea. A comprehensive perspective on the geographical dispersion of accidental pollution events is presented in figure 1.

On a detailed perspective, the raw data has emphasized that 247 localities in Romania were affected, involving either large city but also small villages.

Table 5. *Most events of accidental pollution recorded by localities (2019-2021)*

No.	Locality	2019	2020	2021	Total	No.	Locality	2019	2020	2021	Total
1	Constanța	13	10	11	34	11	Brazi	1	1	3	5
2	Iași	5	6	7	18	12	Foeni	0	0	5	5
3	Sighișoara	0	7	7	14	13	Moinești	3	2	0	5
4	Ploiești	3	7	2	12	14	Boldești Scăieni	0	4	1	5
5	Năvodari	4	5	3	12	15	Oradea	1	3	1	5
6	Târgu Mureș	3	3	5	11	16	Satchinez	0	0	5	5
7	Băicoi	5	2	3	10	17	Sânicolau Mare	0	0	5	5
8	București	1	6	1	8	18	Cuza Vodă	1	3	1	5
9	Cristești	2	3	1	6	19	Ucea	1	3	1	5
10	Buzău	2	1	2	5	20	Slobozia	2	3	0	5

The analysis has shown that the largest occurrence for the entire interval was observed for Constanța (34 events), Iași (18), Sighișoara (14), Ploiești (12), Năvodari (12), Târgu Mureș (11), Băicoi (10). Based on a single year analysis the most recorded events by localities are presented in table below (table 5).
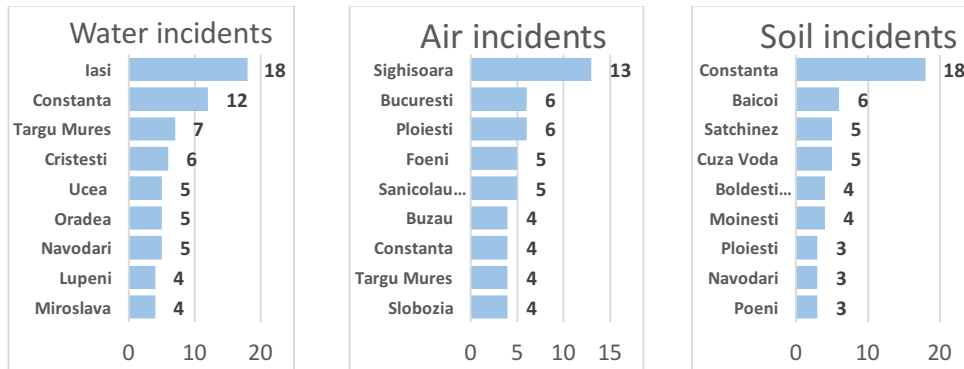

Fig. 2. *Total accidental pollution events by settlements in Romania (2019-2021)*

159

The geographical distribution of the settlements that have been affected by accidental pollution events is presented in map below (figure 2). Despite their relative scattered distribution on the national territory, it can easaly be observed that some clusters have been formed. Thus, the most obvious clusters are those developed around Constanţa, the southern part of Prahova county, the eastern part of Brăila county, around Bucharest and in the center part of Argeş county.

On the affected environmental factor-based analysis the result has shown a slightly different perspective (figure 3). Thus, concerning air targeted accidental pollution events, the most mentioned localities were: Sighişoara (13 events), Bucureşti (6), Ploieşti (6), Foeni (5), Sânicolau Mare (5), Buzău (4), Constanţa (4), Slobozia (4) and Târgu Mureş (4). The geographical distribution of the air targeted accidental pollution events is presented in figure 4.
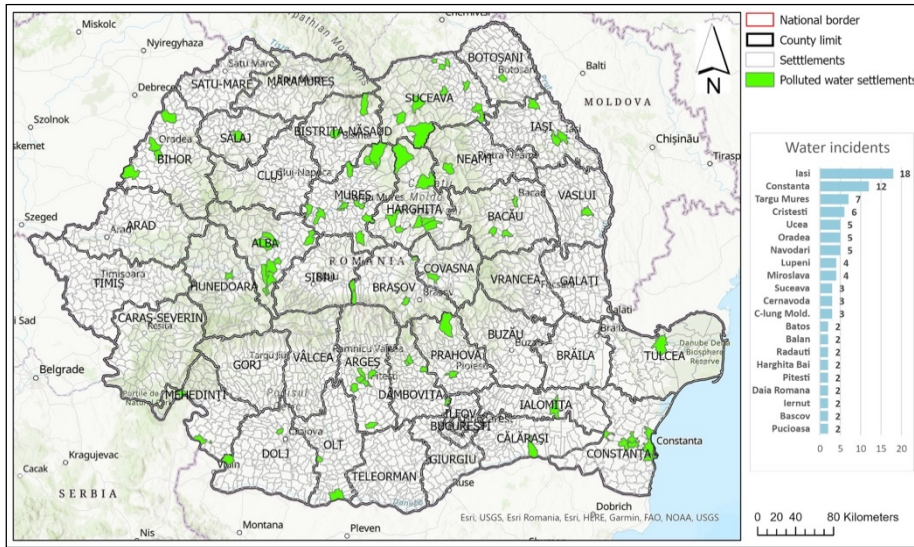

Fig. 3. *Most affected settlements by accidental pollution of a specific environmental factor in Romania (2019-2021)*
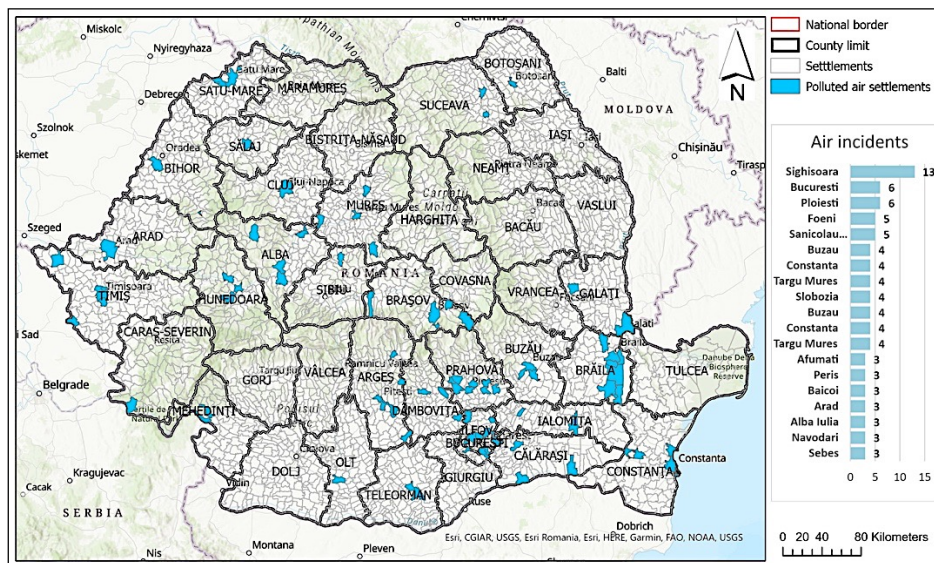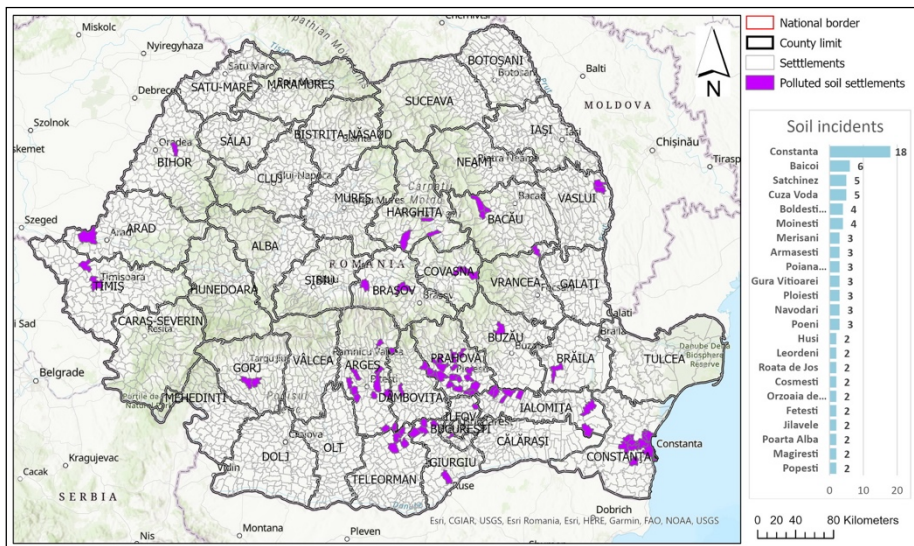

Fig. 4. *Total air accidental pollution events by settlements in Romania (2019-2021)*

160

Regarding water pollution incidents the most frequent observations were associated with: Iaşi (18 events), Constanţa (12), Târgu Mureş (7), Cristeşti (6), Năvodari, Ucea, Oradea (5), Lupeni (4) and Miroslava (4). Tha spatial distribution of the settlements affected by water pollution events is presented in figure 5.

Fig. 5. *Total water accidental pollution events by settlements in Romania (2019-2021)*

Fig. 6. *Total soil accidental pollution events by settlements in Romania (2019-2021)*

The analysis for soil, as targeted environmental factor, has revealed that the most mentioned settlements were: Constanţa (18 events), Cuza Vodă (5), Satchinez (5), Boldeşti Scăieni (4) and Moineşti (4). The spatial distribution is presented in figure 6.

161

Analyzing the pollutant nature and the occurrence on settlements result have shown that the most common substance responsible for accidental pollution are: hydrocarbons, fires and wastewaters.

Thus, hydrocarbons, as the most involved substance in environmental accidental pollution has affected settlements that are economically linked with petroleum industries, while fires cand occurs even due to traffic incidents. Wastewater's evacuation incidents were connected to unforeseen events that are affecting water supply systems, wastewater treatment plants, different pipes infrastructure etc. Most affected settlements by those three major responsible pollutions are presented in the figure below (figure 7).

The most incidents pollution with hydrocarbons were recorded in the following settlements: Constanța (30 events), Năvodari (9), Băicoi (6), Foeni, Cuza Vodă, Sânicolau Mare, Ploieşti, Moineşti, Satchinez (each one with 5 events).
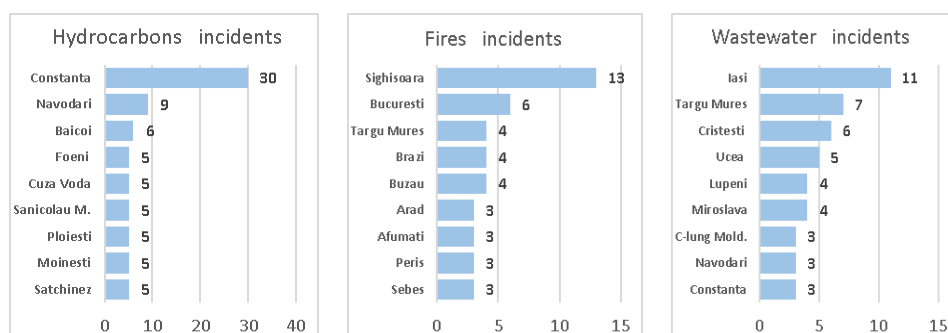
Fig. 7. *Most affected settlements by accidental pollution with a specific pollutant agent in Romania (2019-2021)*

Regarding the fire incidents most affected settlements have been: Sighişoara (13 events), Bucureşti (6), Târgu-Mureş, Brazi, Buzău (4), Arad, Afumaţi, Periş and Sebeş (3). The most cases of accidental pollution, in which the polluting factor was represented by the wastewater were registered in the following settlements: Iaşi (11 events), Târgu Mureş (7), Cristeşti (6), Ucea (5), Lupeni, Miroslava (4), Câmpulung Moldovenesc, Năvodari and Constanța (3).

4. CONCLUSIONS

Accidental pollution events are occurring based on non-predictable scenarios and can affect the quality of the environmental factors for long time. These are sudden events, that are generated usually, independent of human will and can triggered a significant change in the state of the environment. The analysis of these events in the last three years (2019-2021) has shown that the most affected regions are those situated in the eastern half of the country. Most vulnerable counties and settlements to these events have either an economical profile that can be sensitive for the environment (oil refineries and related activities that involve hydrocarbons)

or they have recorded disruptions, structure failures, insufficient maintenance or mis behavior of different activities that have led to environmental pollution.

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163