AGH Journal of Mining and Geoengineering • Vol. 37 • No. 2 • 2013

http://dx.doi.org/10.7494/mining.2013.37.2.43

*Maciej Michałowski**, *Grzegorz Gęgotek**, *Barbara Tora***

AN EVALUATION OF THE IMPACT THE KRAKÓW-SZARÓW A4 MOTORWAY SECTION HAS HAD ON THE ENVIRONMENT

1. Introduction

The purpose of this article is to provide an analysis of the newly built A4 motorway section, and the impact this has had on the local environment. Essentially the impact on soil as well as the air was analyzed. The current regulation on site planning has introduced an ecological factor into development as a basic criterion for overall site planning. At all levels of planning (national, regional and local) the necessity for respecting these objectives is paramount. Ecological objectives are therefore considered to be superior [13].

2. Kraków-SzarówA4 motorway — general information

The A4 motorway between Kraków and Szarów [1] and the environmental impact this has had on the environment is the subject of discussion The 19 km long section, starts at the 436th km, of the A4 motorway and ends at the 455th km. The highway belongs to what is known as 'class „A" — a two-lane motorway, 3.75 m in width with a 3 m emergency lane. The speed limit on the stretch of road is 140 km/h.

3. Terrain characteristic and localization description

The project was divided into two sections:

— Section I situated in the south-eastern part of Krakow — XII Prokocim–Bieżanów district and within the municipality od Wieliczka,

* AGH University of Science and Technology

— Section II administratively is located within the following counties: Niepołomice and Kłaj in Wieliczka county [2, 3].

Fig. 1. Part of A4 motorway — Wieliczka intercharge

The project comes under the małopolskievoivodship and is a part of A4 motorway. The initial section of the motorway (Wielicka interchange) runs away from a residential area, with the exception of sections which intersect with roads where the surrounding area is more agricultural/residential. At the 439th +300 kilometer, the motorway approaches the Kraków – Przemyśl PKP railway line and runs parallel with it for a distance of approximately 40 m. The terrain the motorway crosses at this section is mainly agricultural, crops, home gardening, uncultivated land and small wooded areas. The second section of the A4 motorway starts in 440th + 000 km near the Kokotów – Brzegi municipality road no. 32 in Kokotów. The route passes near the Kraków – Tarnów railway line at the se 439th + 300– 443rd + 500 km section where residential buildings are situated. Further, from the 443rd + 500 to 445th + 900 it runs through the terrain of Podłęże city, and then from the 447th + 000 km, the route runs through the valley of the Podłężanka river, and through the next 9 km it goes through areas with the following surrounding villages: Zakrzowiec, Zagórze, Staniątki, Brzezie and Targowisko. Here the motorway mainly cuts through areas with meadows, houses and gardens. Stand density around the motorway is negligible [4, 5]. According to information from the Niepołomice Forestry Commission, the motorway intersects the animal migration trail in the region of Winnica forest. Taking the facts above into consideration, an animal crossing was planned and later constructed at the 449th + 900 km in Staniątki city, which allows animals to cross

the motorway under its run. Close to this construction the 4 Natura 2000 network of: Koło Grobli, Lipówka, Puszcza Niepołomicka and Wielkie Błoto peat land, were also adopted after a decision made by the commission on January 10th 2011, pursuant to Council Directive 92/43/EEG, can. A fourth updated list of regional Continental biogeographical importance has also been drawn up and established (2011/64/UE). However, this project does not interfere with the investment and further to this it has been established that there are no other potential areas meeting with the criteria of Habitats Directive and bird sanctuary with a European ranking. Along with the natural characteristics of the 4 areas of Natura 2000, the following parameters were also accomplished: A4 Motorway:

— Road class — motorway „A”,
— Speed — 120 km/h,
— Traffic category — KR6,
— Load — 115 kN/os,
— Lane width — 3.75 m,
— Hard shoulder — 3.0 m,
— Soft shoulder — 1.25 m,
— Central reserve with bands — 0.5–5.0 m,
— One-sided cross fall — 2.5%.

4. Research methodology

In the analysis, two factors were taken into consideration: atmospheric air and soil. The assessment of the impact on water quality will be the subject of separate analysis [12]. Four air quality measurements were taken at points situated in such a way as to reflect the level of air pollution in given section [6]. The following measurements for air quality were carried out:

— nitrogen oxide,
— nitrogen dioxide,
— sulfur oxide,
— particulate matter PM10.

The first stage — determining the size of pollutants emitted into the air — was carried out by using COPERT III software for the calculations.

The largest impact on the air quality of the area under investigation is caused by traffic, and to be more specific:

— Traffic and generic structure of the vehicles,
— Technical condition of the vehicles,

— Chemical composition of used fuels,
— Engine load,
— Road characterization,
— Traffic flow,
— Road surroundings.

5. Research results

The results of the tests are presented in tables 1–3 and in Figure 2. The comparison presented concerns the air pollution concentration obtained through direct measurements with values affecting the decision number WM.55021-43/11.

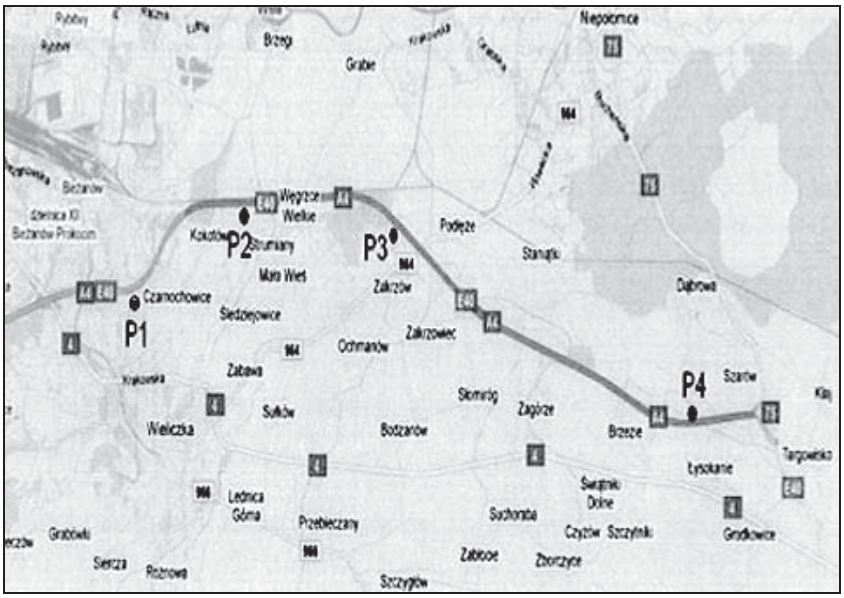

Fig. 2. Highway A-4, Kraków – Szarów, points of sampling

On the basis of these results a model of spreading of pollution was created. Figure 3. shows the maximum average annual and hourly concentrations of NO_x. Soil was the second factor taken into account. To determine the current level of soil contamination bordering the A4 motorway, 20 samples were taken from the depths ranging from 0–30 cm deep. Tested soil samples were qualified as group B — agricultural or building land (points away from the road 25–100 m) or to group C — at the communication area (intersection). Tables 2 and 3 show the results of 20 samples taken from the surrounding area of the A4 motorway.

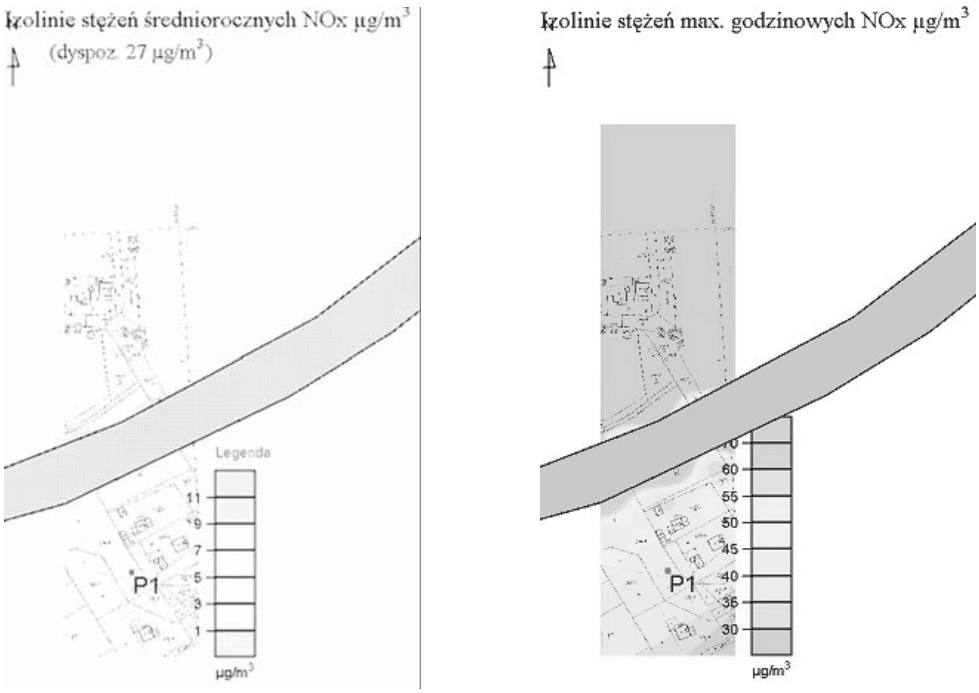

Fig. 3. Isolinies of NO_x concentration

TABLE 1

Results of the investigation

Source / Parameter	Direct measurement Average from 24 h, [pg/m^3]				Decision WM.55021-43/11*) 16.03.2011
	P1	P2	P3	P4	
SO_2**)	88	55	99	88	66
NO_2***)	112	88	117	117	223
PM10***)	99	111	111	116	336
NO_x**)	14	99	223	226	229

*) The background level of pollution used in the region was obtained from the Kraków Provincial Inspectorate for Environmental Protection for SO_2, NO_2, PM10 at a level noted at the time the report was compiled (letter WM.5021-150/04 from August 5th 2004), while for NO_x was assumed to be 10% of the limit value, in accordance with point 1.1 of annex no. 3 of the Minister's Environment regulation' from January 26th 2010 on reference values for several substances in the air (Dz.U. Nr16, poz. 87) [1].

**) Plant protection criterion.

***) Protection of human health criterion.

TABLE 2

Results of physicochemical analysis of soil

No. of point	Zinc, [ng/kg]	Cadmium, [ng/kg]	Copper, [ng/kg]	Nickel, [ng/kg]	Lead, [ng/kg]	Benzin overall (C8-C12), [ng/kg]	Mineral oil (C12-C35) , [ng/kg]	Benzene, [ng/kg]	Ethylobenzene, [ng/kg]	Toluene, [ng/kg]	Xylene, [ng/kg]	Stirene, [ng/kg]	Sum of aromatic, [ng/kg]	pH index
Permitted level	300	4	150	100	100	1	50	0,1	0,1	0,1	0,1	0,1	0,1	–
PPG 1	34,8	< 0,50	3,86	8,12	16,4	< 5,0	< 30,0	< 0,200	< 0,200	< 0,200	< 0,400	< 0,200	< 0,400	7,68
PPG 2	59,9	0,75	8,89	16,9	23,3	< 5,0	< 30,0	< 0,200	< 0,200	< 0,200	< 0,400	< 0,200	< 0,400	7,46
PPG 3	39,5	0,63	7,45	19,4	19,5	< 5,0	< 30,0	< 0,200	< 0,200	< 0,200	< 0,400	< 0,200	< 0,400	7,74
PPG 6	57,7	0,99	8,05	11,0	25,3	< 5,0	< 30,0	< 0,200	< 0,200	< 0,200	< 0,400	< 0,200	< 0,400	6,43
PPG 7	31,1	< 0,50	4,63	7,86	17,2	< 5,0	< 30,0	< 0,200	< 0,200	< 0,200	< 0,400	< 0,200	< 0,400	6,39
PPG 8	32,1	0,56	6,21	6,62	172	< 5,0	< 30,0	< 0,200	< 0,200	< 0,200	< 0,400	< 0,200	< 0,400	6,14
PPG 10	13,9	< 0,50	< 2,40	3,71	20,2	< 5,0	< 30,0	< 0,200	< 0,200	< 0,200	< 0,400	< 0,200	< 0,400	6,31
PPG 12	40,0	0,65	14,3	3,39	23,0	< 5,0	< 30,0	< 0,200	< 0,200	< 0,200	< 0,400	< 0,200	< 0,400	6,47
PPG 14	100	1,46	16,0	13,0	35,6	< 5,0	< 30,0	< 0,200	< 0,200	< 0,200	< 0,400	< 0,200	< 0,400	7,23
PPG 16	41,1	0,62	6,55	5,23	23,9	< 5,0	< 30,0	< 0,200	< 0,200	< 0,200	< 0,400	< 0,200	< 0,400	7,07
PPG 18	35,1	0,51	5,78	5,40	23,0	< 5,0	< 30,0	< 0,200	< 0,200	< 0,200	< 0,400	< 0,200	< 0,400	6,03
PPG 20	43,8	0,73	4,10	5,35	18,8	< 5,0	< 30,0	< 0,200	< 0,200	< 0,200	< 0,400	< 0,200	< 0,400	6,49

TABLE 3

Results of physicochemical analysis of soil

No. of point	Zinc, [ng/kg]	Cadmium, [ng/kg]	Copper, [ng/kg]	Nickel, [ng/kg]	Lead, [ng/kg]	Benzin overall (C8-C12), [ng/kg]	Mineral oil (C12-C35) , [ng/kg]	Benzene, [ng/kg]	Ethylobenzene, [ng/kg]	Toluene, [ng/kg]	Xylene, [ng/kg]	Stirene, [ng/kg]	Sum of aromatic, [ng/kg]	pH index
Permitted level	1000	15	600	300	600	500	3000	100	200	200	100	60	200	–
PPG 4	45,2	0,70	8,70	18,5	19,0	< 5,0	< 30,0	< 0,200	< 0,200	< 0,200	< 0,400	< 0,200	< 0,400	7,95
PPG 5	64,2	1,00	10,7	17,5	26,1	< 5,0	< 30,0	< 0,200	< 0,200	< 0,200	< 0,400	< 0,200	< 0,400	7,23
PPG 9	11,7	< 0,50	2,42	< 3,20	17,1	< 5,0	< 30,0	< 0,200	< 0,200	< 0,200	< 0,400	< 0,200	< 0,400	6,36
PPG 11	68,2	< 0,50	3,88	4,47	23,1	< 5,0	< 30,0	< 0,200	< 0,200	< 0,200	< 0,400	< 0,200	< 0,400	7,83
PPG 13	16,6	< 0,50	2,80	< 3,20	22,3	< 5,0	< 30,0	< 0,200	< 0,200	< 0,200	< 0,400	< 0,200	< 0,400	6,32
PPG 15	56,0	0,54	4,24	< 3,20	23,3	< 5,0	< 30,0	< 0,200	< 0,200	< 0,200	< 0,400	< 0,200	< 0,400	7,71
PPG 17	26,5	< 0,50	4,93	9,72	9,17	< 5,0	< 30,0	< 0,200	< 0,200	< 0,200	< 0,400	< 0,200	< 0,400	6,90
PPG 19	34,8	< 0,50	3,91	10,6	15,7	< 5,0	< 30,0	< 0,200	< 0,200	< 0,200	< 0,400	< 0,200	< 0,400	7,75

6. Results

6.1. Air

The results of tests carried out at the A4 motorway section between Kraków and Szarów establish that air quality limits in this area had not exceeded any limits. This demonstrates that the motorway is no threat to the environment or the people residing in the surrounding area. Data used to establish this was calculated on the basis of direct measurements carried out at 4 points along the motorway as well as a computational model specifically built for this purpose [7, 8, 9]. Currently there is no need to take any measures to correct or reduce the level of pollutants emitted as a result of the combustion of the fuels in the engines of the vehicles driving on this specific section of A4 motorway.

6.2. Soil

The study carried out on the 20 samples of soil was divided into two groups: B — points away 25, 50 and 100 m from the road, C — points localized on the road, did not demonstrate any excessive levels of harmful substances such as, copper, zinc, cadmium, etc. One exception did however occur in one sample in which the lead level was exceeded, however, this was deemed to be un-related to the motorway due to the fact, that three other points from the same cross-section had between seven and ten times lower lead concentrations [10, 11]. As with the air tests, it was established that it was not necessary to take any action to improve or reduce pollution.

REFERENCES

[1] *Derma J. i in.*: Raport oddziaływania przedsięwzięcia na środowisko. Budowa Autostrady A4 węzeł Wielicka – węzeł Brzesko. Km 436+000 – 479+000 (nowy km), km 426 + 000 — 469 + 000 (stary km), TRANSPROJEKT Krakowskie Biuro Projektów Dróg i Mostów Sp. z o.o., Kraków, sierpień 2005.

[2] Uchwała Nr XXIII/178/2004 Rady Gminy Kłaj z dnia 1 października 2004 r. w sprawie miejscowego planu zagospodarowania przestrzennego Gminy Kłaj obejmującego miejscowości: Dabrowa, Grodkowice, Targowisko w ich granicach administracyjnych z wyłączeniem terenów objętych uchwał Rady Gminy Kłaj Nr XII/79/99 z dnia 29 listopada 1999.

[3] Uchwala Nr XXI/168/2004 Rady Gminy Kłaj z dnia 30 lipca 2004 r. w sprawie miejscowego planu zagospodarowania przestrzennego Gminy Kłaj obejmującego miejscowości Gminy: Kłaj, Łężkowice, Łysokanie w ich granicach administracyjnych z wyłączeniem terenów objętych uchwała Rady Gminy Kłaj Nr XII/79/99 z dnia 29 listopada 1999.

[4] Uchwała Nr XXXIX/295/2006 Rady Gminy Kłaj z dnia 24 lutego 2006 r. w sprawie miejscowego planu zagospodarowania przestrzennego Gminy Kłaj obejmującego miejscowości gminy: Brzezie i Szarów w ich granicach administracyjnych z wyłączeniem terenów objętych uchwała Rady Gminy Kłaj Nr XII/79/99 z dnia 29 listopada 1999.

[5] *Tworek S. i in.*: Ocena oddziaływania na środowisko projektu budowlanego „Budowa autostrady A4 — Węzeł Wielicka — Węzeł Brzesko" dla odcinków I i II, w zakresie obszarów Natura 2000, TRANSPROJEKT Krakowskie Biuro Projektów Dróg i Mostów Sp. z o.o., Kraków, 2005.

[6] *Bohatkiewicz J. i in.*: Pomiary zanieczyszczenia gleby w sąsiedztwie planowanej autostrady A4 na odcinku Kraków–Szarów, Biuro ekspertyz i Projektów Budownictwa Komunikacyjnego „EKKOM" Sp. z o.o., Kraków, grudzień 2007.

[7] Decyzja o Ustaleniu Lokalizacji autostrady A4 nr 4/98 wydana przez Wojewodę Krakowskiego w dniu 30.12.98 r., pismo nr RP.II.7331/04/98.
[8] Opracowanie wyników pomiarów ruchu przeprowadzonych w 2000 roku, mgr inż. Krzysztof Opoczyński.
[9] Metoda prognozowania emisji zanieczyszczenia powietrza od pojazdów — model i program komputerowy CopertIII pod redakcja dr inż. Janusza Bohatkiewicza.
[10] Transport — opis działalności w 2009 r., Informacje i opracowania statystyczne GUS, 2009.
[11] Rozporządzenie Ministra Środowiska z dnia 9 września 2002 r. w sprawie standardów jakości gleby oraz standardów jakości ziemi (Dz. U. Nr 165, poz. 1359).
[12] *Klojzyk-Kaczmarczyk B.*: Ocena zagrożeń zanieczyszczeniem rtęcią wód podziemnych w wyniku oddziaływania wybranych odcinków drógna obszarze centralnej Polski ROŚ Annual Set The Environment Protection. ISSN 1506-218X 2011, str. 1767–1782.
[13] *Gawroński K.*: Miejscowe planowanie przestrzenne jako narzędzie ochrony i kształtowania środowiska, ROŚ Annual Set The Environment Protection. ISSN 1506-218X, 2002, str. 49–495.