Environment Protection Engineering

Vol. 14 — 1988 No. 3–4

LEONARD INDEKA*

BENZO(a)PYRENE (BaP) CONTENT IN POTATOES AND OTHER VEGETABLES CULTIVATED WITHIN THE ZONE OF PETROCHEMICAL PLANT EMISSION IN PŁOCK

The benzo(a)pyrene contents in vegetables and potatoes cultivated around the refinery and petrochemical plant in Płock have been estimated. The concentrations of this cancerogenous compound in plants decreased with the distance from the plant. The leafy vegetables have accummulated considerably higher BaP contents than seeds and roots of the vegetables examined (ca 3 times more). Consequently, the leafy vegetables production in the allotments in Płock should be forbidden, as their contamination is hazardous to human health and life.

1. INTRODUCTION

The polycyclic aromatic hydrocarbons are widely known as one of the most cancerogenous compounds. The most active is benzo(a)pyrene (BaP). The coal-fired furnaces and motor vehicles are the main sources of BaP emission. The coking and coal processing plants as well as the refineries also take part in that pollution. The refinery and petrochemical plant in Płock has been in a state of activity for over 20 years and processed about $12 \cdot 10^6$ t of petroleum per year. It is the largest plant of this kind in Poland and second one in Europe, after the Shell Company in the Netherlands. Apart from various kinds of contamination, the plant emits about $17 \cdot 10^3$ t of hydrocarbons to the atmosphere, including benzo(a)pyrene [7].

The aim of the study was to determine BaP content in plants cultivated in allotments of Płock and surroundings. The concentrations of that cancerogenic component in various plants and their parts, taking into account the distance from the source of emission, have been investigated.

* Warsaw Agricultural University, Department of Environment Protection, ul. Nowoursynowska 166, 02–766 Warszawa, Poland.

2. MATERIAL AND METHODS

The sampled plants have been cultivated in three allotments in Płock, Proboszczewice, and Sanniki. Their location varied, depending on the distance from the petrochemical plant:

POD "Chemik" located 0.5 km south from the plant,
POD "Medyczna" located 2.5 km south-west from the plant,
POD "Nadwiślański" located 5 km south from the plant,
Proboszczewice village located 15 km north from the plant,
Sanniki village located 30 km south-east from the plant.

One should remember that Płock is located south of the petrochemical plant and therefore all allotments within the city area are situated on that side.

Benzo(a)pyrene content has been determined in following plants: red beet (leaves and roots), potato (haulm and bulbs), spinach (leaves), field pea, vetch and horse bean (sprouts and seeds).

The BaP extraction and determination have been performed according to the LISIECKA and KALINOWSKA [6], BORKOWSKA, DUKWICZ, and STRUSIŃSKI [1] methods, and Polish Standards (PN/C-04544.0). The dried and grinded plants were subjected to extraction with benzene in Soxhlet apparatus. The preliminary purification due to extraction with petroleum benzine was carried out in the column of silica gel, the first 6 cm^3 have been discarded. The collected fraction was condensed and brought streak by streak on the chromatoplate (DC-Alufolien Kiesegel 60, Art 5553 by Merck) along with silver nitrate (10% solution of $AgNO_3$ in methanol) applied earlier up to 2/3 of the column height. The chromatogram was developed first with petroleum benzine, then after drying out with the mixture of n-hexane and toluene (1:1). After identification, the BaP spots were washed out with n-hexane and the fluorescence intensity was determined spectrophotometerically (SPECOL, Carl Zeiss, Jena, wavelength of 365 nm).

3. RESULTS AND DISCUSSION

Table shows the average BaP content (2-year investigation) in the sampled parts of plants ("Chemik", "Medyczna", and "Nadwiślański" allotments). The considerable diversity of the BaP content has been observed between superficial parts of plants (i.e., sprouts) and hidden ones (i.e., seeds, roots). BaP concentrations in the sprouts and leaves were considerably higher than those stated in seeds, roots, and bulbs of potatoes. The highest concentrations of this cancerogenous compound have been found in the leaves and roots of red beet, and the lowest in the sprouts of vetch and the seeds of field pea and horse bean. Taking into account the BaP contents in plants, depending on the distance from the place of their cultivation to the source of emission, we can clearly distinguish their higher concentrations in vegetables

Table

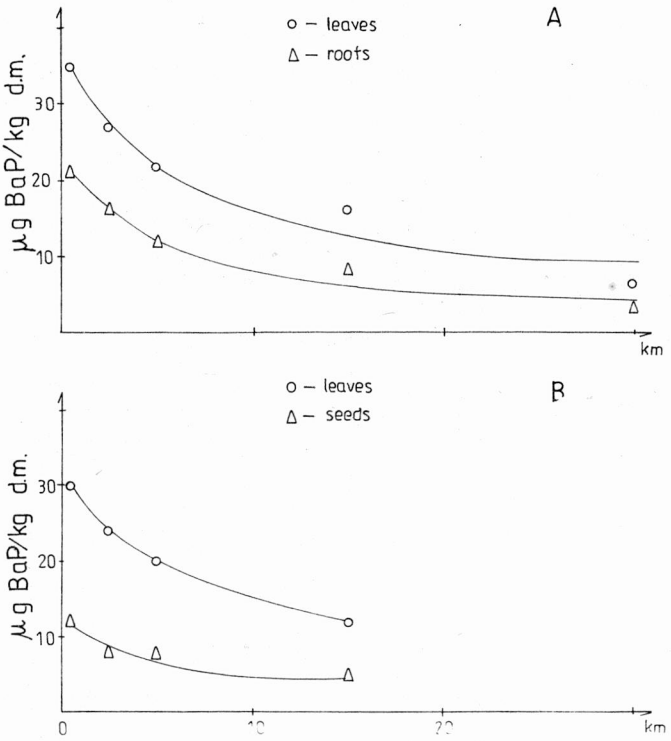
Benzo(a)pyrene content (μg BaP/kg d.m.) in sampled parts of potatoes, red beet, spinach, field pea, vetch, and horse bean

Place of sampling	Potatoes		Red beet*		Spinach*	Field pea		Vetch		Horse bean	
	sprout	bulbs	leaves	roots	leaves	sprout	seeds	sprout	seeds	sprout	seeds
POD "Chemik"	26	13	44	29	39	26	10	24	12	39	13
POD "Medyczna"	24	8	29	23	23	22	9	22	8	28	8
POD "Nadwiślański"	18	11	25	16	20	18	8	17	9	26	7
Proboszczewice	11	8	21	8	15	12	4	10	5	14	5
Sanniki	—	3	6	3	8	—	—	—	—	—	—

* The average values from two-year investigations (for POD "Chemik", POD "Medyczna", and POD "Nadwiślański")

collected in the gardens located closely to petrochemical plant. The farther from the source of emission, the lower BaP concentration has been found in plants (figure).

After some time, the benzo(a)pyrene emitted to the atmosphere subsides, causing pollution of water, soil, and plants. Vegetables and fruits containing that cancerogenous element might be brought into nutrition chain and became a threat for human health and life.



A – Average concentration of BaP in leaves (potato vines) and roots (bulbs) of red beet and potatoes.
B – Average concentration of BaP in leaves and seeds of field pea, vetch, and horse bean

According to SIEWNIAK [8], the respective BaP concentrations in atmosphere in the vicinity of petrochemical plant varied from 540 to 36 μg/m^2 per month for the area close to plant and the area 15–20 km distant from it. The highest BaP concentration in soil (15.1–24.1 μg/kg) has been found in the neighbourhood of the petrochemical plant. At the distance of 5 km from the plant the BaP content was below 0.2 μg/kg.

The relation between BaP concentration in plants and their distance from the source of emission has ben investigated by many scientists [1]–[4], [9]. They proved

that the smaller the distance from the source of emission, the higher concentration of cancerogenous elements in plants. It has been also found that superficial parts of plants (i.e., leaves, fruit peel, etc.) accumulated higher concentrations of BaP than the hidden ones.

Different species accumulate various BaP concentrations. SIEWNIAK [8] confirmed the results obtained by Grimm and Hildebrand who stated that among vegetables the highest accumulation of benzo(a)pyrene was found in the cabbage leaves (24.5 μg/kg d.m.), lettuce (12.8 μg/kg d.m.), spinach (7.4 μg/kg d.m.), and leek (6.6 μg/kg d.m.). The authors expect that such differences in cancerogenous element contents resulted from different morphology of leaves of those plants. The wax-covered and plicated leaves are dust adhesive and thus BaP absorbing.

The results of our investigation presented in the table show the differentiation in cancerogenous element accumulation in examined vegetables.

JANYSZEWA [5] estimated the amount of BaP introduced to human body during 70 years-life on the basis of its content in food. The lowest content of the cancerogenous compound in food amounts to 5 mg; however, if food comes from highly polluted region, the amount of BaP grows up to 70 mg. FRITZ and ENGST [3] calculated that the content of cancerogenous element accumulated through 70 years of live ranges within 24–85 mg. The mentioned authors pointed out that potatoes, vegetables, fruits, and vegetable oil are the main sources of BaP in the human diet.

On the basis of our own finding concerning the BaP content in potatoes and vegetables cultivated in allotments in Płock (POD "Chemik", "Medyczna", "Nadwiślański"), the threat of benzo(a)pyrene food poisoning has been estimated (assuming that crops are taken only from the above area). As the table shows, the average BaP content in potatoes was found to be 11 μg/kg d.m. which in comparison with raw potatoes equals to ca 3 μg BaP/kg (potatoes contain ca 75% of water). The average yearly consumption of potatoes in Poland has been estimated to be 150 kg per person, which makes 450 μg of BaP per one person per year. During 70 years life the statistical inhabitant of Płock would introduce 31.5 mg of BaP into his body. It should be added that in Poland consumption of vegetables and fruits is found to be 100 and 50 kg per year per person, respectively. In the case of vegetables (see the table) their BaP contents are approximately two times higher. Therefore the amount of this compound introduced into human system (over 60 mg during 70 years life) should be considered very high and dangerous.

On the basis of our research it can be stated that vegetables (plants) cultivated within Płock area contain large contents of BaP. Particularly it concerns the leafy vegetables which accumulate BaP in concentrations three times higher than those found in the case of seeds, roots, and bulbs. Therefore their cultivation in that region should be forbidden as their contamination makes them dangerous to human health and life. BaP contents in vegetables cultivated away from Płock (Proboszczewice, Sanniki) were found to be several times lower than those in vegetables within Płock area.

REFERENCES

[1] BORKOWSKA M., DUKWICZ A., STRUSIŃSKI A., *Wpływ transportu samochodowego na zawartość benzo(a)pirenu w glebie i roślinach*, Roczn. PZH., 33, 297 (1982).
[2] ENGST R., FRITZ W., *Zanieczyszczenie żywności węglowodorami rakotwórczymi pochodzącymi ze środowiska*, Roczn. PZH., 26, 113 (1975), 113–118.
[3] FRITZ W., ENGST R., *Zur umweltbedington Kontaminationen von Lebensmitteln mit krebserzeugende Kohlenwasserstoffen*, Z. ges. Hyg., 17, 271 (1971).
[4] GÓRSKA E., GÓRSKI T., *Benzo(a)piren w glebie i ziemniakach*, Bromtologia i chemia toksykologiczna, 12, 257 (1980).
[5] JANYSZEWA N., *O kompleksnom podchode k izučenii benzo(a)pirenu v okružajuščej srede*, Problemy Higieny, Warszawa 1979.
[6] LISICKA J., KALINOWSKA E., *Zastosowanie metody chromatografii cienkowarstwowej do oznaczania 3,4-benzopirenu w pyłach zawieszonych*, Biul. Służby San.-Epid. Woj. Katowickiego, 4, 453 (1970).
[7] NOWAKOWSKI W., *Wpływ emisji przemysłu rafineryjno-petrochemicznego na wzrost roślin warzywnych oraz ich skład chemiczny*, Rozpr. Nauk. SGGW-AR, Warszawa 1982.
[8] SIEWNIAK M., *Badania nad zanieczyszczeniem powietrza i gleby wokół zakładów petrochemicznych w Płocku*, Zesz. Nauk. SGGW-AR, Rozpr. Nauk., 53, Warszawa 1975.
[9] ZIMNY H., NOWAKOWSKI W., *Wpływ emisji przemysłu petrochemicznego na zawartość 3,4-benzopirenu w kilku gatunkach warzyw*, Problemy Higieny, [in:] Mat. Konf. Nauk. "75-lecie działalności Oddziału Łódzkiego PTH", 1977.

ZAWARTOŚĆ BENZO(a)PIRENU (BaP) W ZIEMNIAKACH I INNYCH WARZYWACH HODOWANYCH W STREFIE EMISJI ZAKŁADÓW PETROCHEMICZNYCH W PŁOCKU

Badano zawartość benzo(a)pirenu w warzywach i ziemniakach uprawianych wokół zakładów rafineryjno-petrochemicznych w Płocku. Stwierdzono, że stężenie kancerogenu w roślinach maleje wraz ze wzrostem odległości od zakładów. Dużą ilość BaP kumulują warzywa liściaste (około trzykrotnie więcej niż nasiona, korzenie czy bulwy roślin). Z tego powodu uprawę warzyw w Płocku należałoby ograniczyć, gdyż nadmiernie skażone stanowią zagrożenie dla zdrowia i życia ludzi.

СОДЕРЖАНИЕ БЕНЗО(А)ПИРЕНА (БаП) В КАРТОФЕЛЕ И ДРУГИХ ОВОЩАХ, ВЫРАЩИВАЕМЫХ В ЗОНЕ ЭМИССИИ НЕФТЕПЕРЕРАБАТЫВАЮЩЕГО КОМБИНАТА В ПЛОЦКЕ

Исследовано содержание бензо(а)пирена в овощах и картофеле, выращиваемых вокруг нефтеперерабатывающего комбината в Плоцке. Установили, что концентрация канцерогена в растениях понижается вместе с ростом расстояния от комбината. Большое количество БаП кумулируют зеленые овощи (ок. троекратно больше, чем семена, корени или клубени растений). Из-за этого овощеводство в Плоцке следовало бы ограничить, ибо сверхискаженные овощи являются опасными для здоровья и жизни людей.