The study of (Columba livia domestica) Pigeon as *bioindicator* of contamination with zinc, lead and cadmium in Khartoum state

Author : Tawassul Mahadi Gassim
Department of Biology - Faculty of Education
University of Khartoum

مجلة
كلية التربية
جامعة الخرطوم
العدد السابع
السنة الخامسة
يناير 2013م
ربيع الأول 1434هـ

الحمام المنزلي (كولمبيا ليفيا دوميستكا) كمؤشر حيوي على التلوث البيئي بالزنك و الرصاص و الكادميوم في ولاية الخرطوم.

د. توسل مهدى قاسم
قسم الاحياء – كلية التربية
جامعه الخرطوم

المستخلص

هدفت هذه الدراسة الى تأكيد ان الحمام المنزلي يعتبر مؤشراً حيوياً جيداً للتلوث البيئٍ بالعناصر الثقيلة مثل الرصاص والكادميوم وأيضا الزنك كعنصر أساسي. لذا جمعت 90 عينة من الحمام من مناطق ريفية، حضرية و مناطق صناعية من ولاية الخرطوم. ذُبح الحمام وأَخذت عينات من الريش ،السيرم، الكبد والكلى للتعرف على محتواها من العناصر الثلاث بواسطة جهاز الامتصاص الذري بعد معالجتها. بناء على النتائج قسمت الأنسجة المستهدفة والسيرم حسب غناها بالعناصرأعلاه الى: السيرم<الكبد<الكلى<الريش بالتتالي، وكذلك الحال بالنسبة للعناصر الثلاثة: الكادميوم<الرصاص<الزنك. صنفت الدراسة المناطق الصناعية على أنها أكثر المناطق تلوثاً بالعناصر أعلاه، واعتبرت الريش مؤشراً حيوياً على التلوث في منطقة الدراسة.

The study of (Columba livia domestica) Pigeon as *bioindicator* of contamination with zinc, lead and cadmium in Khartoum state

Author: Tawassul Mahadi Gassim
Department of Biology - Faculty of Education
University of Khartoum

Abstract:

The objective of the study is to provide evidence that pigeon is a good bioindicator of environmental pollution with Pb and Cd as heavy metals and Zn as trace element. Ninty samples of *Columba livia* were collected from rural, urban and industrial areas in Khartoum State. The birds were killed and metal concentrations were tested with atomic absorption spectrophotometer after treated by wet ash procedures. The results divided serum and target tissues according to richest with metals in thes order: serum> liver> kidney> feather and the three metals Cd> Pb> Cd respectively. The study showed that industrial areas are the richness area with Zn, Pb and Cd and considers feathers as the best monitor of air pollution in the study area.

Introduction

Feral pigeons live in old building in rural areas and skyscrapers In cities (Roof, 2001). *Columba livia domestica* is widely distributed in the Sudan with many breeds which exhibit a very wide range of size, shape, color, form and behavioral characteristics according to Venkatraman and Badawi (1969). Schilderman *et al*.(1997) and Gabol *et al*. (2003) reported that pigeons can be used as biological indicators on exposure to heavy metals pollution outdoors. The habits of feral pigeons of feeding at ground level on pavement and in gutter of the roads offer an explanation of the very high metal content in their blood such as lead (Lumeij 1985). Close correlation exists between the residues in pigeon eggs and the study sites especially traffic density or building pattern (Nagel *et al*. 2001).

The environment pollutants like copper, cadmium and zinc inhibit the metabolism of the organism and show toxic effect (Das. 1990). Zinc is known to be an essential mineral that enters food materials from the soil through mineralization by crops or environmental contamination with metal based pesticides (Salama and Radwan 2005). Most of the body zinc is found in the liver, bones, epidermal tissue, feather and the blood. It is a very common substance that occurs naturally (Campbell and Lasley 1975). Large concentration of zinc can cause serious health problems (Clarke *et al* 1981). Lead and its compounds can be highly toxic when eaten or inhaled and find their way to liver and kidneys (U.S.EPA 2000). Harmful exposures to lead can be created when lead-based paint is improperly removed from surfaces by dry scraping, sanding or upon flame burning La Bonde, (1995). pigeons exposted to lead poisoning show anorexia and ataxia followed by excitement, loss of weight and egg production, fertility and decrease in hatchability and mortality may be high Clarke et al. (1981). Cadmium is a toxic metal (U.S.EPA 1996) and large quantities of Cd are found in commercial phosphate fertilizers (Vallee and Ulmer 1972 and WHO 1992). Cadmium accumulates first in the liver and then in the Kidney for 20-30 years. The chief clinical signs observed were postmortem lesions, anemia, enlarged spleen, icterus, ulceration of the stomach and fat degeneration of liver and kidneys (Clarke et al., 1981).

The present study aimed to quantify the level of zinc, lead and cadmium in the feather, serum, kidney and liver from rural, urban and industrial areas from Khartoum, Khartoum North and Omdurman, Sudan.

Materials and Methods:

Sampling of pigeons *C. livia*

A total of ninty adult pigeons Columba livia were collected from three villages in rural areas (Sarurab, Derasah and Wad ajeeb), three cities (Elqamier, El haj Yusuf, Tuty and Elshejarah) as urban areas and three industrial areas (Omdurman, Khartoum and Bahri) in Khartoum State. Thirty specimens were collected from each area. Feathers were collected to observe their zinc, lead and cadmium content. The feathers were thoroughly washed with acetone and then washed twice with distilled water to remove loosely adhering contaminants. The feathers were then transferred to clean watch glass vials and dried at room temperature and then treated according to Fry, (2004). For observation all birds from each area were killed by dislocation, serum, livers and kidneys were collected in bags and frozen for Zn, Pb and Cd analysis. Atomic absorption spectrophotometer (Perkin Elmer) was used for measurement of metals according to the method described by Valoon, (1980).

Determination of Zn, Pb and Cd in serum

Serum was diluted 1:5 with deionized water as reported by Frenandez and Khan, (1971) to determine its metals content.

Determination of Zn, Pb and Cd in tissues

The Wet ashing, oxidation procedure was followed describe by Kahnke, (1966); Parker *et al*. (1967) for determination of metals in tissue was used.

Determination of Zn, Pb and Cd in feather

This method involves a wet ashing (digestion) process. The samples were prepared as reported by Kopito *et al*., (1967); Harrison *et al*., (1969).

Statistical analysis:

Data collected from experiments, were analyzed using SPSS for windows version 11.0 (Mauchly's test). Differences were considered significant where $P<0.05$.

T-test was applied for differences between samples in experiment. All data were expressed as Mean ± SD.

Results:

The results showed a great variation in mean metal concentrations in different tissues. The results showed that concentration was lowest in the three study areas (rural, urban & industrial), where as Zn and Pb showed high levels with almost similar concentration demonstrated. The highest concentration of Cd was found in Kidneys. The richness of tissues concentration with the three metals was in the following order: serum< liver <kidney <feather and with metals Cd< Pb< Zn respectively in (Table1).

Table 1 The mean concentration of metals in serum and target tissues of 90 *C.livia* collected from 3 areas in Khartoum state.

Metal / Tissues	ZN Mg/dl	Pb Mg/dl	Cd Mg/dl
Serum	0.125 ±4.76	0.129 ± 8.96	6.46 ±5.78
Liver	0.218 ± 9.84	0.167 ± 0.137	5.07 ±3.07
Kidney	0.231±0.161	0.174±0.126	6.640 ± 1.326
Feather	0.321±7.084	0.281±7.56	9.55 ±0.12974

Values represent mean ± standard deviation

Pigeons collected from rural areas showed that the levels of Zn were much higher than Pb and Cd in serum, liver and kidney respectively but in feather Pb was the highest metal (Table 2).

Table 2 Descriptive statistics of metals concentrations in 30 C. livia collected from 3 Rural areas.

Metal / Tissue	Zn Mg/dl	Pb Mg/dl	Cd Mg/dl
Serum	0.106±.008	9.81 ±0.016	7.420 ±0.011
Liver	0.203±.018	9.90 ±.023	3.88 ±0.005
Kidney	0.155±0.027	0.124 ±0.015	5.350 ±0.012
Feather	0.277±0.012	0.297±0.012	0.147±0.023

Values represent mean of 30 samples± standard error
(M ± St. Error)

Different samples collected from urban areas showed a great variation in metal concentrations as shown in (Table 3).

Table 3 Descriptive statistics of metals concentrations in 30 *C. livia* collected from 3 urban areas

Metal / Tissue	Zn Mg/dl	Pb Mg/dl	Cd Mg/dl
Serum	0.112 ±0.002	0.123 ±0.016	5.797 ±0.011
Liver	0.236 ±0.018	0.157 ±0.023	4.020 ±0.005
Kidney	0.207 ±.027	9.307 ±.015	7.273 ±0.012
Feather	0.334 ±0.012	0.231±0.012	6.377 ±0.023

The mean values of metals (Zn, Pb and Cd) in different tissues were the highest in industrial areas (Table4).

Table 4 Descriptive statistics of metals concentrations in 30 *C. livia* collected from 3 industrial area

Metal / Tissue	Zn Mg/dl	Pb Mg/dl	Cd Mg/dl
Serum	0.158±0.008	0.169±0.016	6.163±0.011
Liver	0.216±0.018	0.244±0.023	7.317 ±0.005
Kidney	0.329±0.027	0.304±0.015	7.30 ±0.012
Feather	0.353±0.012	0.315±0.012	7.590 ±0.023

From the descriptive statistics of serum and target tissues a significant correlation between the three study areas was observed and there was a significant correlation between metal levels and study areas.
The present study divided areas according to richness as follows: rural<urban<industrial. (Fig1, Fig2, Fig3, Fig4).

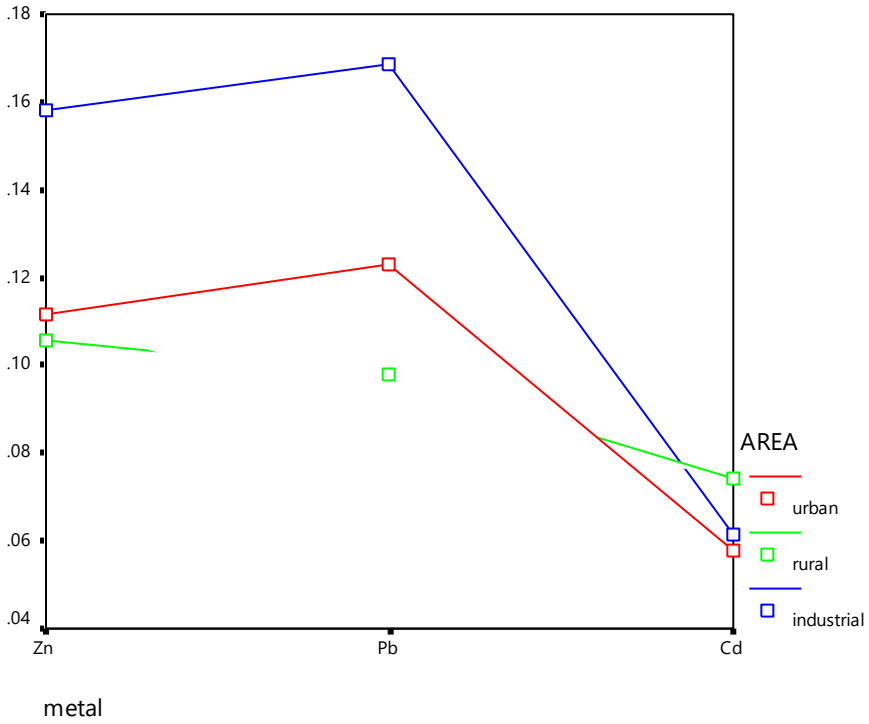

Fig1: The mean metal Zn, Pb and Cd concentrations in serum in the 3 study areas (rural, urban and industrial)

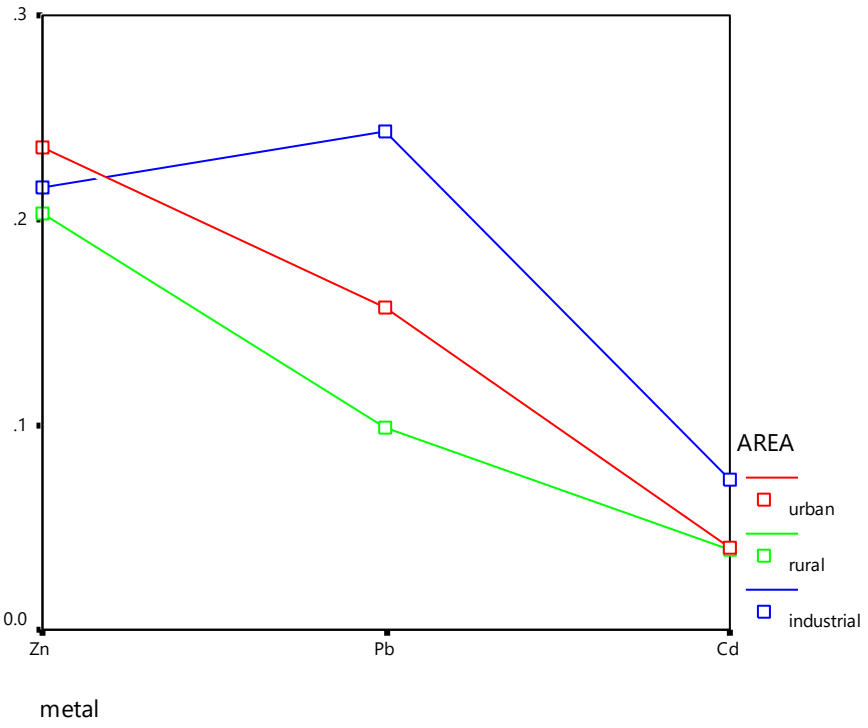

Fig 2: The mean metal Zn, Pb and Cd concentrations as deter mind in liver in the 3 study areas (rural, urban and industrial)

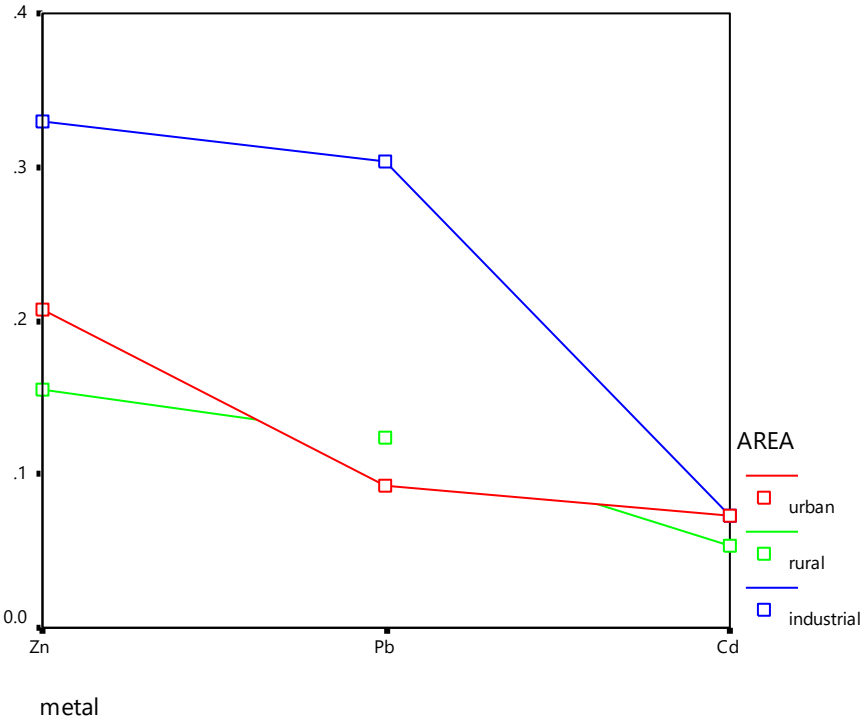

Fig3: The mean metal Zn, Pb and Cd concentrations of kidney in the3 study areas (rural, urban and industrial)

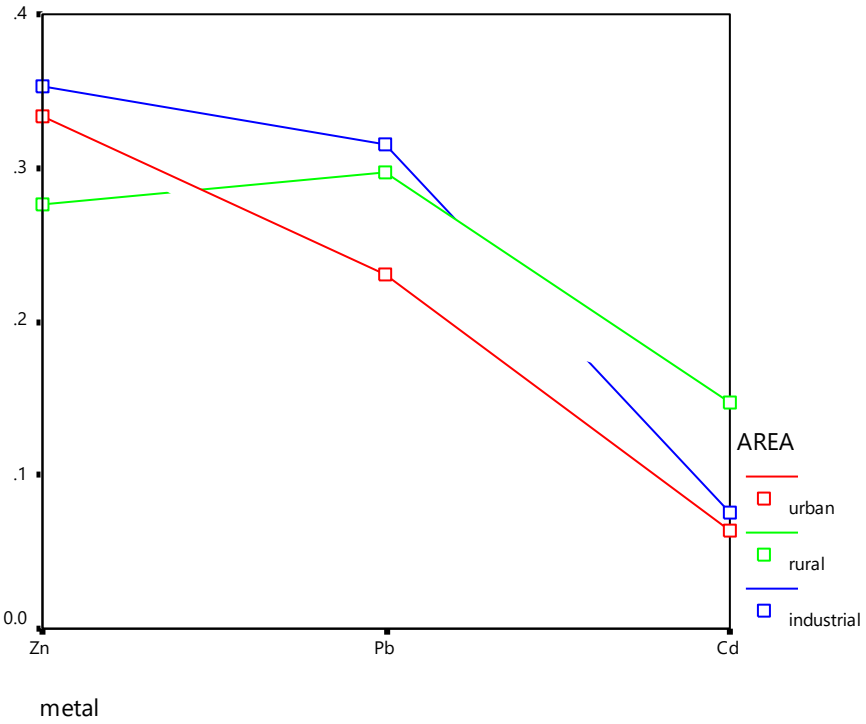

Fig4: The mean metal Zn, Pb and Cd concentrations in feather in the 3study areas (rural, urban and industrial)

Discussion:

Burger and Gochfeld, (1991) reported that birds acquire heavy metals through the food chain, from preening contaminated material of feather, or from drinking water contaminated by industrial effluents, agricultural runoff, air pollution, fallout, natural erosion and biochemical cycles. The results of the present study showed that feathers can serve as a monitor for air pollution due to high levels of Zn, Pb and Cd especially in feather of pigeons from industrial areas. These finding agree with many investigators Gochfeld and Burger (2000) and Dauwe *et al*., (2003). Ohi *et al*., (1980) suggested that the street pigeons are a handy and sensitive indicator of regional lead pollution. Schilderman *et* al., (1997) found that wild city pigeons were caught from four different locations in Netherlands to represent areas of high, moderate and low traffic density. The higher Pb and Cd concentration in blood, liver and lungs were found in high traffic density area. They concluded that pigeons can be used as biological indicators on exposure to heavy metal pollution in outdoor air. Nam *et al*., (2004) investigated lead exposure condition by using unwashed feather of feral pigeon as monitor for lead pollution in rural, urban and four industrial complex areas, they indicated that external contamination of the feather surface may be an important source for lead levels in feathers rather than transfer from internal tissue lead. Nam and Lee, (2006a) indicated that Pb accumulation in tissue of pigeon may be affected by Pb exposure in their respective habitats. Swaileh and Sansur, (2006) reported that adult sparrows collected from rural areas were found to have significantly less Cu, Pb and Zn but not Cd concentrations than those collected from urban area in Palestine. In the present study, the concentrations of Zn were highest in all tissues analyzed and those of Cd were clearly the lowest, the levels of Pb were much higher than Cd in all organs. Antonio et al., (1988) suggested that pigeons gave a greatly magnified picture of lead pollution in cities than indicated by atmospheric lead concentration. The lead and cadmium concentrations in tissues of pigeon did not decrease as atmospheric metal levels decreased. Nam and Lee, (2006b) suggested that ingestion may be more important than inhalation on exposing pigeons to Pb and Cd.

This study found that kidneys follow the feathers in high content of metals than liver, although Swaileh and Sansur, (2005) found that

concentrations of metals in tree sparrow were high in liver and bones and low in muscles. The liver is the site of detoxification in the body and this explains its high metal content. Habitat preferences of pigeon *(Columba livia)* and their habits of feeding as reported by Lumeij, (1985) and Nagel et al., (2001), explain various levels of Zn, Pb and Cd in the tissues of pigeon during the present study.

This study shows that the environment of Khartoum state suffers from several environmental problems, such as contamination with Zn, Pb, and Cd at various levels. Sachs, (1985) reported that rural areas in Khartoum are often even worse of services than those of cities, but it is the high population density of the latter which creates or aggravates health problems. In urban areas the most rapid growth takes place in uncontrolled squatter settlements where services are absent. Barakat., (2010), El-Sdeeq, (2010) and Osman, (2010) reported that services such as garbage removal are lacking or absent in many areas in Khartoum and neighboring areas. Urban and industrial areas do not only emit pollutants but they are also characterized by a high pollutant input consisting of numerous xenobiotics from many different sources (Nagel *et al*., 2001). Traffic density in Khartoum, which uses lead gasoline is a good source of metal pollution as reported by Kenntner *et al*., (2003) and Swaileh and Sansur, (2005). Food items taken from contaminated location can be expected to become contaminated with lead containing dust or trace elements from street dirt as reported by Hutton and Goodman, (1980); Hutton, (1980) and Plessow et al., (1997). Ventilation, temperature and humidity can affect the toxic potential of many airborne toxins. Smoke from cooking or burning or cleaning agents are frequent causes of inhalant toxicities in pet birds as indicated by La Bonde., (1995). The pollutants are transported, diluted and modified chemically or physically in the atmosphere and finally reach some receptors, where they damage health or some other part of the environment according to Haj Musa, (2008), that means contamination has serious economic effects. Finally Khartoum state is considered as a complicated town, it could be divided to suburban, urban and industrial town at the same time.

Table (1) : Screening of the effect of fungal spores on germination and growth of Striga and sorghum seeds in pouches :

treatment	number of striga plants/pouch	sorghum plant height (cm)	sorghum root length (cm)	sorghum shoot fresh weight (g)	sorghum shoot dry weight (g)	sorghum root fresh weight (g)	sorghum root dry weight (g)	sorghum nUmber of leaves/ plant
Untreated (ds)	5.50a	35.2b	24.6ab	2.0c	0.45d	2.578b	0.5675b	7.25ab
Ds + F01	0.01c	39.9ab	29.2ab	2.7bc	0.69bcd	1.78b	0.55b	7.75ab
Ds + F02	0.051c	42.8ab	34.3ab	4.9abc	1.22abc	2.93b	1.03ab	8.25a
Ds + F03	0.76c	43.4ab	30.1ab	4.8abc	1.12abcd	3.09b	0.81b	8.75a
Ds + F04	0.10c	42.3ab	38.3ab	4.3abc	0.9abcd	6.60ab	1.05ab	7.5ab
Ds + F05	2.00bc	41.3ab	33.6ab	3.5bc	0.75bcd	3.67b	0.84ab	7.5ab
Ds + F06	0.26c	46.5ab	29.9ab	3.6bc	0.83bcd	1.85b	0.65b	7.75ab
Ds + F07	0.75c	43.3ab	37.0a	4.3abc	094 abcd	2.49b	0.68b	8.0ab
Ds + F08	1.50c	48.4ab	33.1ab	3.8abc	0.89abcd	2.65b	0.78b	8.0ab
Ds + F09	0.26c	38.5ab	31.8ab	2.2c	0.47d	1.49b	0.50b	7.75ab
Ds + F10	0.51c	41.6ab	27.1ab	2.9bc	0.70bcd	1.84b	0.69b	8.0ab
Ds + F11	0.01c	45.7ab	25.7ab	2.0c	0.54cd	1.54b	0.39b	7.8ab
Ds + F12	0.76c	55.2a	35.5ab	5.6ab	1.33b	4.03b	1.78ab	8.5b
Ds + F13	0.10c	47.5ab	33.5ab	4.1abc	0.99abcd	2.41b	0.71b	8.25a

Ds + F14	0.51c	46.5ab	37.6a	3.5bc	0.92abcd	2.40b	0.88ab	7.25a
Ds + F15	4.00ab	54.9a	32.8ab	6.7a	1.58a	7.92ab	1.58a	8.75a
Ds + F16	1.75c	44.9ab	22.6b	3.2bc	0.81bcd	2.09b	0.07b	6.5b
Ds + F17	0.01c	41.5ab	26.3ab	3.4bcd	0.73bcd	11.43a	0.76b	8.0ab
Ds + F18	1.26c	47.6ab	27.6ab	3.6bc	0.81bcd	2.54b	0.67b	7.25ab
Ds + F19	0.26c	51.2ab	32.6ab	3.7abc	0.94abcd	2.06b	0.66b	8.0ab
Ds + F20	0.01c	45.8ab	28.5ab	3.1bc	0.73bcd	2.08b	0.66b	8.0ab

*Values in the same column followed by the same letter(s) are not significantly different by Duncan Multiple Test .

All isolates were identified as A. niger except F06 and F19

Ds = sorghum + Striga F = fungus

References:

1 -Antonio, G. M. T., Martines, C. E. and Corpas, V. I. (1988). **Lead Levels of Feral Pigeons (Columba livia)** From Madrid (Spain). Environ. Pollut. 54(2): 89-96.

2 -Barakat, R. (2010). **EAfrootan Tannery**. Eltiar news paper. Issue No. 158. 26th Jan 2010.p:5 .

3n-Burger, J. and Gochfeld, M. (1991). **Cadmium And Lead In CommonTerns (Sterna hirundo) Relationship Between Levels In Parents And Eggs. Environ**. Monit. Assess. 16: 253-258, 1991. Kluwer Academic Publishers, Nertherland.

4-Campbell, B. and Lasley, F. J. (1975). **The Science Of Animals That Serve ManKin**d. 2nd ed. McGraw- Hill Book Company.

5-Clarke, M. l.; Harvey, G. D. and Humphreys, J. D. (1981). **Veterinary Toxicology**. 5th ed. Bailliere Tindall, Cassel Ltd, London.

6n-Das, A. (1990). **Metal Ion Induced Toxicity And Detoxification By Chelating Therapy In.** 1st ed. A text book on medical aspects of bioinorganic chemistry, CBS, Delhi. P.17-58.'

7 -Dauwe, T.; Bervoets, L.; Pinxten1, R.; Blust, R. and Eens, M. (2003). **Variation Of Heavy Metals Within And Among Feathers Of Birds Of Prey**: Effects Of Molt And External Contamination. Environmental Pollution. 124(3): 429- 436. ElSEVIER, Ltd.

8 -ElSdeeq, A. (2010). **South Khartoum**: "Landfills and anarchy of bags". ElTiar News paper, issue No. (170), P.5, 7Feb2010.

9 -Frenandez, F. J., and Khan, L. H. (1971). **Clinical Chemistry.** New(1). Clinical method for atomic spectroscopy.

10 -Fry, M. (2004). **Analysis Of Lead In CaliforniaCondor Feathers**: Determination of exposure and depuration during feather growth. Calif. Dep. Fish and Game, Habitat Conservation Planning Branch, species. Conservation and recovery program report, 2004. Sacramento, CA.18.

11 -Gabol, K.; Tabassum, R. and Khan, M. (2003). **Induced Effect Of Cadmium Chloride On Rock Pigeon (Columba livia**). J. hist. wild l. Vol.2, No.1: 39-43.

12 -Gochhfeld, M. and Burger, J. (2000). **Biological Concentration Of Cadmium In Estuaria Birds Of New York Bight**. JSTOR; Colonial Water birds. 5, P. 116-123. 2000-2007.

13 -Haj Musa, R. H. M. (2008). **Environmental Management: Air pollution in Khartoum industrial area. M.Sc, Faculty of Engineering. Dep. Of chemical engineering**, UofK. June 2008.

14 -Harrison, W. W; Yurachek, J. P. and Benson, C. A. (1969). **The Determination Of Trace Elements In Human Hair By Atomic Absorption Spectroscopy**. Clin. Chim. Acta. 23,83.

15 -Hutton, M. (1980). **Metal Contamination Of Feral Pigeons (Columba livia) From The London Area:** Part2. Biological effects of lead exposure. Environmental Pollution. Ser A, Ecol Biol. 22(4): 281-293.

16 -Hutton, M.and Goodman, G. T. (1980). **Metal Contamination Of Feral Pigeons (Columba livia) From The London Area**: Part1.Tissue accumulation of lead, cadmium and zinc. Environmental pollution Ser A, Ecol Biol. 22(3): 207- 217.

17 -KahnKe, M. J. (1966). **Atomic Absorption Spectroscopy Applied To The Determination Of Zinc In Formalinized Human Tissues**. Absorpt. News(1).

18 -Kenntner, N.; Krone, O.; Altenkamp, R.; and Tataruch, F. (2003). **Environmental Contamination In Liver And Kidney Of Free- Ranging Northern Goshawks (Acceipiter genitilis) from three regions of Germany**. Environ. Contami. Toxicol. 45: 128-135. Springer- Veriag, NY.

19 -Kopito, L.; Byers, R. K. and Shwachman, H. (1967**). Lead In Hair Of Children With Chronic Lead Poisoning**. New Engl. J. of Med. 276, 949.

20 -La Bonde, J. (1995). **Seminars In Avian And Exotic Animal Medicine**." Toxicity in Pet Avian Patients".St. lowis, Mo.W. B. Saunder. Vol. 4, No.1: 23-31.

21 -Lumeij, J. T. (1985). **Clinicopathologic Aspects Of Lead Poisoning In birds: a review paper. The Veterinary Quarterly.Vol7, No.2: 133-136.**

22 -Nagel, P.; Smrekar, G. and D.Haag-Wackernagel. (2001). **Use Of Pigeon Eggs For Urban Biomonitoring**. Fresenius Environmental Bulletin (FEP). PSP, 10(1): 18.

23-Nam, DH.; Lee, DP., and Koo, TH. (2004). **Monitoring For Lead Pollution Using Feathers Of Feral Pigeons (Columba livia) from Korea**. Environ. Monit. Assess.Jul. 95(1-3): 13-22.

24 -Nam, DH and Lee, DP. (2006a). Possible **Roles For Lead Accumulation In Feral Pigeons (Columba livia)** . Environ. Monit. Assess.

25 -Nam, DH and Lee, DP. (2006b**). Monitoring For Pb And Cd Pollution Using Feral Pigeons (Columba livia) In Rural**, Urban And Industrial Environments Of Korea. Sci. Total. Environ. Mar.15. 357(1-3): 288-95.

26 -Noordwijk, M. V. (1983**). Ecology Textbook For The Sudan**. 1st ed. Juba/ Groningen. U of K, Sudan. Sep1980- Dec 1983.

27 -Ohi, G.; Seki, H., Minowak, K.; Mizogachi, I. and Sugimon, F. (1974). **Acute Lead Poisoning Of The Pigeon Induced By Single**, Intrapentioneal Administration Of Lead Acetate. Arch. Toxicol. 46(3-4): 72-265.

28 -Osman, A. (2010). **Landfill Of AlAlafoon**. ElRay Elaam news paper. Issue No. 4454. 24th Feb.2010. P: 9.

29 -Plessow, A.; Plessow, k. and Heinrichs, H. (1997). **Schadstoffbelastung Von Strassenkehricht And Sedimenten Der Regenwasserkanalisation Durch Den Strassenverkehr Am Beipsiel Von**. Gollingen, Umweltwissenschaften U. Schadstoff- Forschung (UWSF), Z Umweltchem OKotox. 9(6): 353-354.

30 -Practical Action Publishing. (2005)**. Smoke And Health In Sudan**: No fire without smoke. A report on the outputs and achievements of Practical Action Sudan's Smoke and Health project in Wau and Kadugli. Sustainable and effective kitchen smoke alleviation, Jan 2005.

31 -Roof, J. (2001). Common Pigeon (Clomba livia). Unversity Of Michigan, Museum Of Zoology., Animal Diversity web. Accessed, 2006.
-Sachs, I. (1985). **Cultivating The Cities. The urban environment: Urban services and environmental health**. Environmental problems in Sudan Part (II). 495-509.

32 -Salama, A. K. and Radwan, M. (2005**). Heavy Metals Cd, Pb And Trace Elements Cu, Zn Content In Some Food Stuffs From The Egyption Markets** . Envir. J. Agric. Sci.17(1): 34-42.

33 -Schilderman, P. A.; Hoogewerff, T.A.; Van Schooten, F.J.; Maas, L.M.; Moonen, E. J.; Van Os, B.J.; Van Wijnen, J. H. and Kleunjans, J.C. (1997). **Possible Relevance Of Pigeons As An Indicator Species For Monitoring Air Pollution**. Environ. Health. Perspect.105(3): 322-350.

34 -US.EPA: "United States Environmental Protection Agency". (1996). **Toxics Release inventory Public Data Release**. US.EPA office of pollution Prevention and Toxics. Washington, DC.

35 -US.EPA: "United States Environmental Protection Agency". (2000). **Lead. US.EPA office of pollution Prevention and Toxics**. Washington, DC.

36 -Vallee, B. L., and Ulmer, D.D. (1972). **Biochemical effects of mercury**, cadmium and lead. Annu. Rev. Biochem. 41:91-128.

37 -Valoon, J. C. (1980). **Analytical atomic absorption spectroscopy, selected methods**. Acadmic Press Inc. Orlando, London.

38 -Venkatraman, T.V. and Badawi, A.T. (1969**). Agricultural Zoology For Students In Africa.** U of K. press.116.
39 -WHO. (1992**). Cadmium: International Programme On Chemical Safety**. Environmental Health Criteria 134. Genova, 1992.