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Urban water pollution by heavy metals and health implication in Onitsha, Nigeria

A. C. C. Ezeabasili[1]*, O. L. Anike[2] and B. U. Okoro[3]

[1]Heriot Watt University, UK.
[2]Nnamdi Azikiwe University, Awka, Anambra State, Nigeria.
[3]Department of Civil Engineering, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria.

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Studies of common heavy metals were conducted at Onitsha, Anambra State, the most urbanized city in Southeastern Nigeria. It was discovered that both surface and subsurface water were heavily polluted. Seven (7) heavy metals namely: arsenic (As^{+2}), cadmium (Cd^{+2}), lead (Pb^{+2}), mercury (Hg^{+2}), zinc (Zn^{+2}), copper (Cu^{+2}) and iron (Fe^{+2}) were studied. Their major sources include wastes like refuse dumps, effluent from industries, sewage, fuel spills from dumps and mechanic workshops, hospital and pharmaceutical wastes, agricultural materials, fossil fuel combustion, metallurgical industries, electronic components and semi-conductors, batteries, pigments and paints. Further data were collected in ongoing research works in the area and public enlightenment was done in a small scale. Recommendations are made to government to note the impending dangers of further urban environmental pollution by these trace metals.

Key words: Polluted, effluents, research, urban.

INTRODUCTION

Effluent from industries in Onitsha, Anambra State, Nigeria, together with sewerage and waste spills from households and markets has become a nuisance in the state. These vary from nuisance from the odour to obstructions of traffic to more serious problems of land degradation and water pollution. It is feared that some of the adverse consequences are the noticed increase in disease incidence especially cancer, kidney infection and damage, as well as problems of the cardiovascular system and gastroenteritis (Agbozu et al., 2001; Rajappa et al., 2010). Industrial effluents and effluent from sewerage, as well as those from households contain solvents and other chemical ingredients that have key heavy metals like arsenic, lead, cadmium and mercury. Wastes also derived from shops and small-scale industries like dry cleaning, bleaching, breweries and hospitals has become numerous and may contain plastics, batteries and unused drugs. These wastes require special control, treatment and disposal methods); the practice of dumping of refuse and wastes is common

*Corresponding author. E-mail: acczeabasili@yahoo.com or ezeabasilialoy@gmail.com.

Table 1. Industries in sampling location (within Onitsha metropolis).

Major industry type	Code	Location	No.	Products
Food, beverage and Tobacco	A	Onitsha	25	Beer, starch and other miscellaneous food products, flavouring, soft drinks, floor and grain milling, meat, poultry and fish, tea, coffee and other beverage, dairy products, etc.
Chemical and Pharmaceutical	B	Onitsha	44	Paints, vanishes, soap and detergents, agro-chemicals, pharmaceuticals, dry cell batteries petroleum products. Toiletries and cosmetics, industrial chemicals
Domestic and industrial plastic, rubber and foam	C	Onitsha	26	Rubber products, plastics, foam
Metal, iron and steel	D	Onitsha	26	Foundry, metal manufacturing & fabrications, aluminum producers, etc.
Electrical and electronics	E	Onitsha	4	Electronics, refrigerators, bulbs, power control & distribution equipment
Textiles, carpet, leather and footwear	F	Onitsha	5	Textile materials, leather products ropes, etc.
Wood and wood products	G	Onitsha	3	Furniture
Non-metallic minerals products	H	Onitsha	8	Glass, ceramic, asbestos, chalk, cement packaging.
Motor vehicle and miscellaneous assembly	I	Onitsha	7	Boat fabrication, automobile manufacturers, etc.

Source: MOI, Anambra State.

in both the old urban areas and the new-urban areas adjoining them (Bhaskar et al., 2010). Efficient waste management requires provision of well selected, designed and operated sanitary landfills. Due to the importance of good water quality, monitoring of pollutants has become imperative. The effectiveness of treating waste before they are released to the environment has been recognized worldwide especially in the developed world, where laws are strictly enforced (Agarwal and Manish, 2011). This is important so as to ensure that permissible concentration of a particular chemical is not exceeded.

Location of study area

Onitsha is located in Anambra State in Eastern Nigeria and lies within latitudes 5°22[1] and 6°48[1] and longitudes 6°32[1] and 7°20[1]. Onitsha in Anambra State is located on the east bank of River Niger and covers an area of about 49,000 km^2. It is one of most important commercial centres in sub-Sahara African, as well as a transit city in Nigeria. It has an estimated population of about one million inhabitants. The socioeconomic characteristics of Onitsha consist of about 75% labour force that is engaged in tertiary sector, such as, trading and services. The remaining 25% of labour force is engaged in manufacturing and industrial activities. However, Onitsha is a centre for the production of local goods and services, as well as, a market for the sale of foreign goods. The Onitsha main market, which is reputed as the largest market in sub-Saharan Africa, has increased the tempo of commercial activities in the city in recent times. There are two main seasons: the dry season, October - March and the rainy season (April - September) approximately corresponding to the dry and flood phase, respectively of the hydrological regime. The vegetation is derived guinea savannah (Awachie and Ezenwaji, 1981).

METHODOLOGY

Random sampling technique was employed in choosing water samples from surface and groundwater samples in Onitsha, Anambra State (Table 2). Water samples were collected in a properly washed and sterilized 500 ml screw-capped glass bottles transported in ice pack and analyzed immediately. An experimental method of research was performed to assess the presence or absence of toxic heavy metals in selected samples and the concentration of each heavy metal when present.

The selected heavy metals were arsenic (As^{+2}), cadmium (Cd^{+2}), lead (Pb^{+2}), mercury (Hg^{+2}), zinc (Zn^{+2}), copper (Cu^{+2}) and iron (Fe^{+2}). Analysis of the heavy metal contents in the water samples was done with the use of the atomic absorption spectrophotometer (AAS).

This method is based upon the absorption of radiant energy, usually in the ultra-violet and visible regions by neutral atoms in the gaseous state. Water sample were stored in 50 ml of PVC bottles, analysis was done using AA210FC, Varian instruments, Fast Sequential, Analytical grade chemicals (HNO_3, Sigma chemicals, Australia and standard heavy metal solutions, Varian instruments, Australia) after preserving at 4°C for a short period of time. Samples for heavy metal analysis were digested using nitric acid (65% purity) as described in the APHA methods (APHA, 2005).

RESULTS AND DISCUSSION

Major sources of pollutants in Onitsha

Effluent discharge from industries

Data from the Ministry of Industries, Anambra State were analyzed statistically (Table 1 and Figure 1). Investigation carried out showed that effluent is discharged directly into

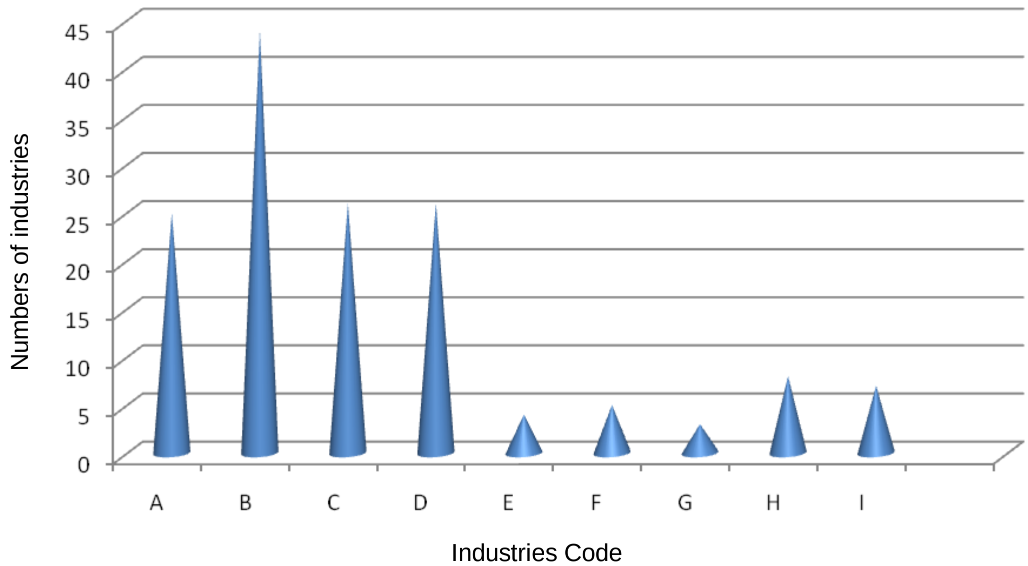

Figure 1. Industrial density in the study locations.

the environment. Motor vehicle and miscellaneous assembly, chemical and pharmaceuticals, domestic and industrial plastic etc, a few of the industrials are located in sampling sites. Onitsha is more prone to pollution because of the vast surface water and the more shallow subsurface water with more permeable soils having little of Imo shale formation. The contributions of these industries are no doubt pronounced in the research results. The skewed distribution of these industries toward the River Niger and Nwangene stream would be responsible for pollution of the rivers. The shallow coastal plain aquifer of the main market environs is also responsible for the ease of pollution of subsurface water in the area (Igwe et al., 2008). None of these industries has any programme for effluent treatment nor are there intense pressures from the government on them to provide for effluent treatment.

Refuse dump sites

Refuse dumps are found in various zones as approved by the Anambra State Environmental Sanitation Agency as well as in zones not so approved. It was discovered that various gully sites are used both by communities, individual households, and the agency for disposal of refuse.

However, the agency has designated two sites each at Omogba phase I and II as final dump sites for the zone. These final dumpsites are not designed landfills and therefore are outlets for the pollution of shallow ground waters around the highly permeable soils of the areas. Other temporary refuse dumps are found at over 20 other sites from where they are emptied in the final dumps at the convenience of the sanitation authority.

Other major dumps are found at Creek road around the Rivers Niger and Nwangene. These dumps constitute the temporary major dumps on land surface of all other dumps in the vicinity. The Ochanga Market and the main markets are also sources of refuse dumps which generate effluent that contain mainly biological and chemical pollutants that contaminate both surface and subsurface water in the coastal area aquifer of the zone.

Fuel (petrol, diesel, kerosene and oil) from filling stations and vehicle exhaust fumes

Fuel filling stations are fastest growing industries in the state. Most of these stations are concentrated along the highways while the rest could be found along major streets of the city. It is therefore easy to identify these stations and their areas of influence where leakages in the underground tanks and spills during discharge pollute the environment. Onitsha has over one hundred and six (106) functional stations. Exhaust fumes of internal combustion engines also contribute to the pollution of soil and water resources in the areas due to the high number of vehicles on the road (Ogbuagu and Ajiwe, 1998).

Previous studies in this area have shown the presence of lead and other heavy metals (Ajiwe, 1996; Ibe, 2000; Okoye, 2004). Although, the values of lead may not have been higher than the WHO standards in many cases, it is feared that the buildup of this metal if not controlled may become major health problems in the next few years. Mechanical workshops, which are spread across Onitsha, are numerous and their contribution to pollution especially lead is obvious. It is also known that car battery and other battery types like those for clocks, torch lights dumped into the system also contribute very much

Table 2. Groundwater and surface water sampled locations.

Sampling points	Code as used in figures 2 and 3
Borehole (Bany water)	1
Borehole (Onitsha South)	2
Borehole (Afasa, Onitsha)	3
Borehole (Life Brewery)	4
Borehole (Metal Industry)	5
Borehole (Otumoye)	6
River Niger (Upstream)	7
Nwagene stream	8
River Niger (Otumoye)	9
River Niger (Central drain)	10

Table 3. Descriptive statistics of heavy metals in sampling points.

Parameter	As	Cd	Pb	Hg	Zn	Cu	Fe
Range	2.61	0.98	1.99	1.91	1.26	0.97	1.24
Minimum	0.00	0.00	0.01	0.00	0.07	0.02	0.12
Maximum	2.61	0.98	2.00	1.91	1.32	0.98	1.36
WHO (2011)	0.01	0.003	0.01	0.006	3.00	2.00	0.30

to the present elevated value of lead in surface and subsurface water (Danquah et al., 2011).

Hospitals

Hospitals are spread over Onitsha and the numbers of private Hospitals have soared because of the confidence of the people and the quick services rendered by the private hospitals. These hospitals, especially the private ones, do not have waste dumps or lined landfills for the special types of pollutants; chemical, biological and even radioactive which emanate from wastes of special drugs and other wastes generated therein. These wastes are either dumped into the popular refuse dumps or buried in shallow dumps. Hospital wastes no matter their quantity remain one type to be given special treatment (Coker et al., 2008). Onitsha metropolis has about 220 hospital/ clinics of different sizes.

Other sources of pollution

Other sources of pollution include soil and gully erosion and flooding that have polluted streams and reservoirs. Presently, soil erosion remains the greatest ecological problem in the state, sewage disposal systems are not adequate and so sewage from septic system, pit latrine also contribute a lot to pollution in the areas as thousands of private and residential buildings have sprung up in the past twenty years. Recent construction works on roads has increased with little attention paid to all the environmental effects of the wastes generated, Agricultural wastes and chemicals are washed down to these cities from the hinterlands. These wastes include nitrate, heavy metals, fluorides and some radioactive wastes that find their way through runoff water to the main rivers of the area and into subsurface water too (Adeyemo and Sangodoyin, 2005).

Appraisal of pollution level in the area of study

Table 3 depicts the concentration of Arsenic level in surface and groundwater samples. Arsenic concentration was between 0.0000 (borehole, Onitsha South) and 2.6058 mg/l (Nwagene stream). Arsenic pollution in these areas are traced to anthropogenic pollution especially industrial pollution, refuse dumps and oil/fuel dumps that get washed down to streams/rivers of these major cities on daily basis (Danquah, 2011). The value of arsenic found in these areas is over and above the world Health Organization standard of 0.01 mg/l in both surface water and the boreholes adjacent and closest to these rivers and streams.

Lead was found in all water samples tested and the average values range from 0.0113 (borehole, Bany water) to 2.0013 mg/l (Nwagene stream). Petrol stations are sited all over the places. Surface spills and leakages from buried tanks that have been operating over 20 years without maintenance pollute water.

Cadmium values as seen in Figure 2 are moderately high with range of 0.0000 to 0.9800 mg/l. As previously discussed, refuse dumps littering everywhere and the reckless disposal of sewage and wastewater, all over the areas are responsible for appreciable high values recorded, with highest values recorded for Nwagene stream.

Apart from the numerous dump sites containing discarded vehicle batteries and small batteries for various uses and some of the manufacturing industrial effluent; appreciable quantities of mercury were detected with

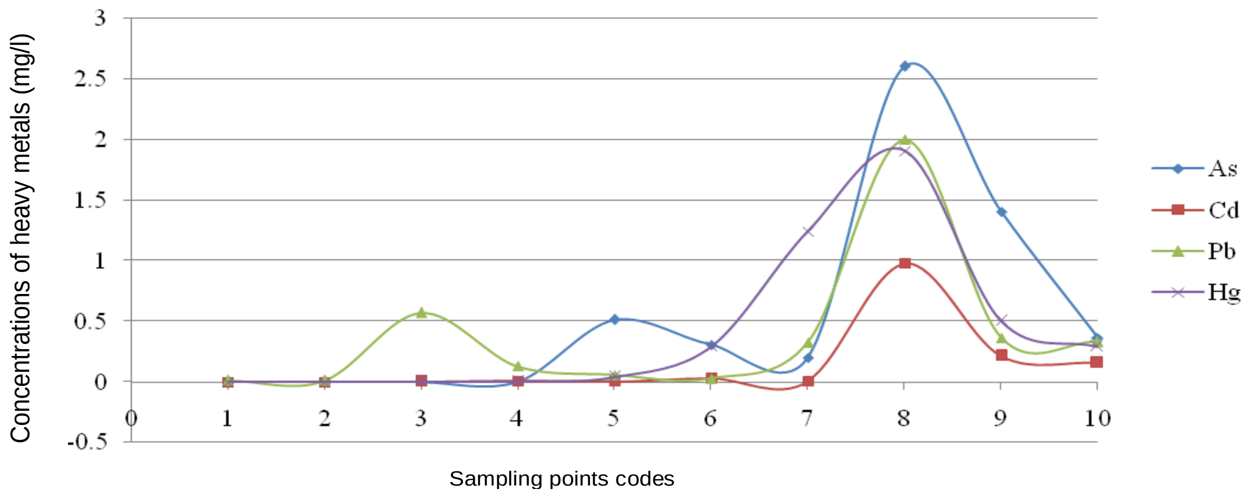

Figure 2. Concentrations of arsenic, cadmium, lead and mercury in the sampling points

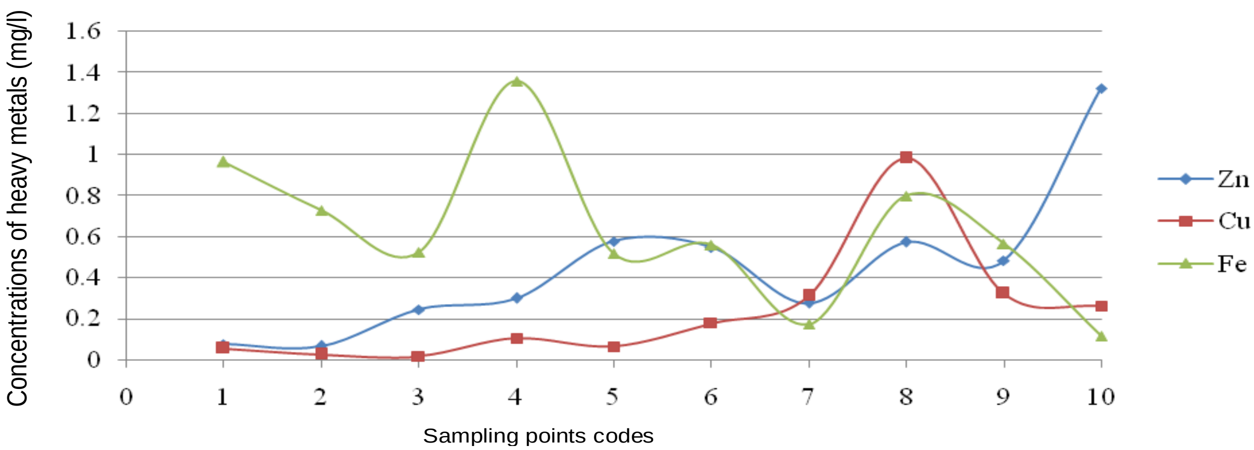

Figure 3. Concentrations of zinc, copper and iron in the sampling points.

values from 0.0000 (borehole Onitsha south) to 1.9076 mg/l (Nwagene stream). Most of the values are far above the World Health Organization standard of 0.006 mg/l.

Zinc is likely to have found its way into the environment from industrial producers in these cities. Galvanized steel is however identified as a major source of zinc in this area. They may come as wire fencing which eventually dissolve in rain and drops to the ground below. Sewage and animal manures has also contributed to the significance presence of zinc in the surface and subsurface water. Onitsha have high values of zinc encountered and this is attributable to the numerous "zinc" roofs that are used for thousands of buildings that have rusted away for up to thirty years in most cases because these are old cities. Fencing with galvanized steel barbed wires and nails are also common contributors. The indiscriminate disposal of sewage and similar wastes from refuse dumps over the areas also contribute to zinc pollution in the area. The standard values for zinc is 3 mg/l for WHO standards. From Figure 3, the highest value of 1.3242 mg/l was recorded at River Niger central drain while the lowest of about 0.0675 mg/l was recorded at borehole (Onitsha South).

Values of copper recorded for both the subsurface water and the surface waters and rivers were generally much lower than the standard set by the WHO (2.0000 mg/l). The highest value of copper recorded in surface water was 0.9829 mg/l at Nwagene stream, and lowest 0.0169 mg/l at borehole (Afasa Onitsha). Copper poisoning is therefore not yet contemplated but the values of copper content remains a pointer to impending problems.

From Table 3, the WHO standard for iron is 0.3 mg/l. The values ranged between 0.1179 (River Niger central drain) and 1.3580 mg/l (borehole, Life brewery). Table 4 reveals that significant interactions exist among

Table 4. Correlation analysis of heavy metals.

	As	Cd	Pb	Hg	Zn	Cu	Fe
As	1						
Cd	0.939**	1					
Pb	0.854**	0.948**	1				
Hg	0.781**	0.811**	0.822**	1			
Zn	0.277	0.274	0.188	0.160	1		
Cu	0.918**	0.957**	0.910**	0.930**	0.308	1	
Fe	-0.003	0.069	0.013	-0.215	-0.524	-0.062	1

**Correlation is significant at the 0.01 level (2-tailed).

heavy metals. At P<0.01, positive correlation existed between arsenic and cadmium (r=0.939), lead (r=0.854), mercury (r=0.781), copper (r=0.918); cadmium and lead (r=0.948), mercury (r=0.811), copper (r=0.957), e.t.c as depicted. Result affirms that some indicator parameters influence presence of others.

Impact of heavy metal pollution

Eni et al. (2011) noted that water pollution results to a gradual decline in general economic life of the populace. At Onitsha, the fish industry is affected by gradual poisoning of fish population in areas and periods of heavy pollution loads. Fish production is also reduced because heavy metals at the level of pollution cause stunted growth of the fishes in the River Niger (Ajiwe et al., 2002). As noted by Rish and Rishi (2011), consumption of fishes and other sea foods from the River Niger over long periods could lead to diseases like cancers of the bladder, liver and intestine, clogging of arteries, hypertension, stroke and heart diseases. This therefore, will lead to reduction of the life expectancy of the people. A general hazard in Onitsha includes the presence of odour and colour in the affected waters. Pollution of surface water affects water supply network, resulting in health risks and increased load on water treatment plants, increase in cost of water treatment and therefore obvious health consequences. The leachates and effluents containing heavy metals also contain organic compounds and synthetic material pollutants and contaminants with long half-lives. These remain hazardous for long time within the hydrogeologic environment and are very difficult to remove. High levels of iron bacteria have caused problems in water supplies, coating on piping systems, impellers and motors that reduce flow rates of pumps, total plugging of the wells after prolonged use. It also affects portability of water. Corrosive ground water easily eats off the screens and pumps of boreholes (Okun et al., 1971).

The effect of heavy metals in these areas of study is chronic in that they have a long term effect on health due to frequent exposure to small amounts. The combination or synergistic effects of these metals are suspected to be responsible for notable ailments like cancer, kidney and cardiovascular diseases as attested for by records in the Nnamdi Azikiwe University Teaching Hospital, Anambra State. From the Public Health Department of the same institution, it is also recorded that symptoms of ailment like tiredness syndrome, lethargy, depression and rheumatoid arthritis are common. Other symptoms of heavy metal pollution encountered in treating patients include white lines across the toenails and finger nails, weight loss, nausea, diarrhoea alternating with constipation, damage of gastro-intestinal track and liver, kidney failure, hypertension and loss of hair all ascribed mostly to arsenic, cadmium and mercury (Ezeabasili, 2008).

It is anticipated that if the pollution of water by heavy metals is not abated, the incidence of the disease would increase and new forms of ailment could be experienced in these urban areas as in other parts of the world with similar experiences.

Conclusion and recommendations

Onitsha is generally littered with refuse dumps. Because of the large population density, the level of pollution is getting increasingly serious. The heavy metals in water come from these refuse dumps, industries, drug containers and hospital wastes, various forms of chemical dumps from the market and small scale industries.

In the light of the findings in this work, the author makes the following recommendations; the introduction of modern, sensitive and reliable methods for testing drinking water for physical, chemical and biological parameters is very important and urgent. The development of adequate infrastructure for water testing laboratories is necessary. The presence of AAS equipment in every institution is recommended. This would increase research work on all our water resources like that obtained in most developed countries now. Secondly, the Anambra State Government should strengthen and enforce existing laws bordering on pollution especially for dangerous chemical effluents from industries. The proper monitoring of industries through environmental impact assessment and environmental audit report (EAR) should be enforced by the Ministry of Environment. It would be better if industrial effluents were treated before discharged. Finally, the Anambra State Government should ensure that the concerned officials of the health departments should report results as and when the water quality deviates from the national and international norms, to the government and the concerning public.

The infrastructure of water quality testing laboratories requires improvement. It is noticed, that various research results cannot be reconciled because of faulty equipment. Water quality reporting system needs considerable change to alert concerned officials in inter-disciplinary sectors. As the drinking water testing laboratories are presently governed by the NAFDAC and Urban and Rural Drinking water supply agencies there should be interaction with health professionals/personnel of other sectors. Health education and health department's interaction need to be introduced and promoted at all levels at frequent intervals.

Conflict of interest

The authors did not declare any conflict of interest.

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