

EFFECT OF THE GAMMA RADIATION ON THE ABATEMENT OF NITROGEN POLLUTION, PHOSPHATE AND DISINFECTION OF TREATED WASTEWATER OF THE WWTP

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Abstract

*This work was conducted to evaluate the efficacy of gamma radiation on the pollution load of the effluent from the East purifying station of Tizi Ouzou. Samples from raw water and treated water were irradiated with Co-60 as source of gamma radiation at a dose of 16 kGy. After irradiation the results showed a significant reduction in NH_4^+ , NO_3^- , NO_2^- and PO_4^{3-} with almost total elimination of fecal coliforms and *Escherichia coli*. The study showed that the combination of Gamma irradiation with conventional biological treatment gives satisfactory rates of abatement of the pollution load with respective returns of 97,77%, 91,34%, 39,32% and of 64,78% on raw waters and of 96,68%, 91,04%, 97,45% and of 53,28% on treated wastewater, thus a yield of 100% was observed on removal of microorganisms.*

Key words: wastewater, gamma irradiation, nitrogen, phosphorus, microorganisms

INTRODUCTION

New technology in the field of municipal wastewater treatment expands continuously. One of complementary techniques used recently in several countries is the use of atomic radiation as a complementary treatment (Maruthi, 2013). Firstly, the irradiation technique allows safe reuse of treated wastewater for irrigation but likewise solve environmental problems very effectively, in particular in the degradation of many organic and inorganic pollutants from water and secondly the inactivation of pathogenic microorganisms (Sumartono, 2008). From this perspective that we tried to focus our research, we applied gamma irradiation on the secondary effluent of the WWTP east of the city of Tizi-Ouzou. For this the Co 60 was used as source and after determining the optimal irradiation dose "16 kGy"

PREVIOUS STUDIES

Several studies on the implementation of the technology of ionizing radiation as a complementary treatment on wastewater were carried out in different countries, including China, India and Morocco. The reason for the use of gamma radiation in the wastewater treatment depends on many facts including:

- The radiation destroys microbial life and this property is considered especially beneficial because it will involve the inactivation of pathogenic micro flora.
- The radiation is capable of modifying the structure of the organic molecules, which leads to a reduction in biological oxygen demand (BOD₅) and chemical oxygen demand (COD) (Al-Ani Mohammed *et al*, 2006).

MATERIAL AND METHODS

The wastewater treatment by irradiation refers to the use of ionizing radiation as an energy source (Sampa *et al*, 2005). However, among the thousands of radioactive elements, ^{137}Cs and ^{60}Co are the only indicated to be used effectively to generate gamma rays (Aquino, 2012). In this work, we applied to raw sewage and treated of the WWTP east of Tizi-Ouzou a source of Gamma radiation ^{60}Co , of the

pilot irradiator of the Nuclear Research Center of Algiers (CRNA) it is composed of three cylindrical ^{60}Co COP4 Type manufactured by ORIS (France).

The absorbed dose can be defined as the amount of energy absorbed by the mass of irradiated material. The unit of measurement used to describe the absorbed dose is the Gray (Wang and Wang, 2007).

RESULTS AND DISCUSSION

The investigations in this study focus mainly on the analysis of different forms of nitrogen and phosphorus as well as on the total germs of raw water and treated in the WWTP east of the city of Tizi-Ouzou before and after irradiation. The evolution of these different forms in the raw and treated water before and after irradiation is given in Table 1.

Table 1. Results of analyzes of different forms of nitrogen and phosphorus of raw water and treated before and after irradiation

Water Type	Raw water		Treated water		Yields (%)	
Irradiation parameters	Before	After	Before	After	Raw water Before / After irradiation	Treated water Before / After irradiation
NH_4^+ mg/l	20,64	0,46	4,83	0,16	97,77	96,68
NO_2^- mg/l	0,0924	0,008	0,78	0,007	91,34	91,04
NO_3^- mg/l	0,132	0,08	9,03	0,23	39,39	97,45
Po_4^{3-} mg/l	4,497	1,75	1,37	0,6	64,78	53,28

Effect of Gamma radiation on the ammonium NH_4^+

The results of the Gamma radiation effect on the ammonium are shown in the figure below:

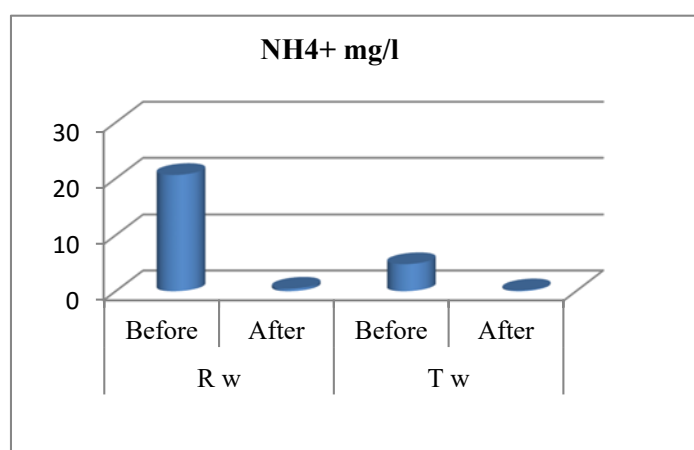


Figure 1. Concentration of the ammonium in the raw water and the uncluttered water before and after irradiation.

The recorded ammonium content at level of raw sewage of Station east of tizi-ouzou is of the order of 20.64 mg / l. It usually indicates an incomplete mineralization process of organic matter when the

amount of oxygen is insufficient. After biological treatment the concentration goes from 20.64 mg / L to 4.83 mg / l with a 76.59% yield.

Moreover, after irradiation at a dose of 16 kGy one notices a significant drop in NH_4^+ ions passing of 20.64 mg / L to 0.46 mg / l with a yield of 97.77% for raw water and 4, 83 mg / l to 0.16 mg / l with a yield of 96.68% for the treated water.

Effect of Gamma radiation on the nitrites NO_2^-

The results of the Gamma radiation effect on the nitrites are shown in the figure below:

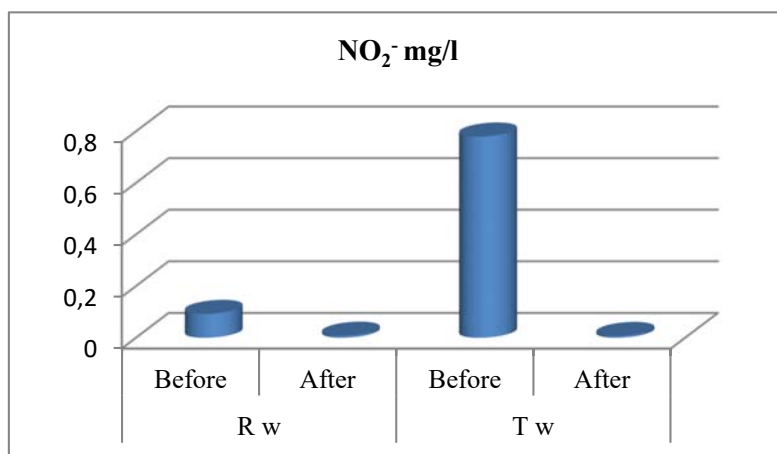


Figure 2. Concentration of the nitrites in the raw water and the uncluttered water before and after irradiation.

The results obtained during the study campaign, show a low level of nitrates. The biological treatment across the aeration basin induces oxidation of the nitrogenous material hence the slight augmentation of 0.0924 mg / L to 0.78 mg / l. After irradiation the nitrite concentration pass of 0.0924 mg / L to 0.008 mg / l with a yield of 91.34% for the untreated water, for the treated water concentration is reduced of 0.78 mg / l to 0.007 mg / l with a yield of 91.04%. However, the concentration of nitrite in the treated effluent, after conjugation of biological treatment and Gamma radiation of 0.0078 mg / l, which is lower than international standards of rejection (<1mg/l) (OMS, 1989).

Effect of Gamma radiation on the nitrates NO_3^-

The results of the Gamma radiation effect on the nitrates are shown in the figure below:

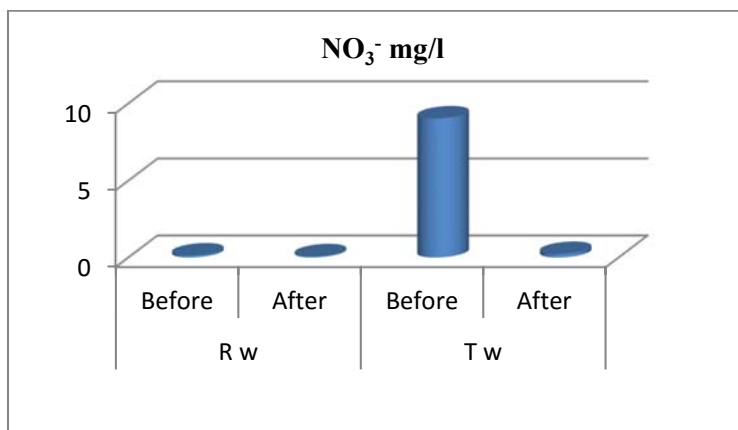


Figure 3. concentration of the nitrates in the raw water and the uncluttered water before and after irradiation.

The results in Table 1 show oxidation of ammoniacal nitrogen whose concentrations move from 0.132 mg / L to 9.03 mg / L in the biological treatment.

After irradiation we note a considerable decrease, with a return of 39.39% for the raw water, and 97.45% for the treated water.

Effect of Gamma radiation on the phosphate ions PO₄³⁻

The results of the Gamma radiation effect on the phosphate ions are shown in the figure below:

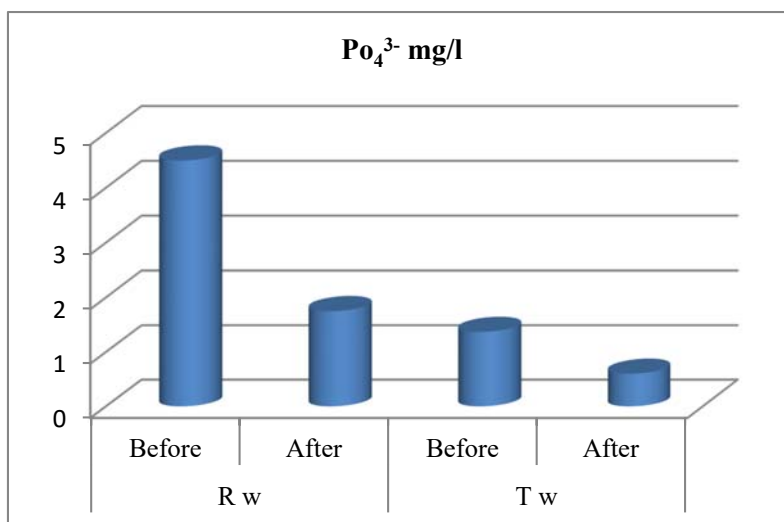


Figure 4. concentration of phosphate ions in the raw water and the uncluttered water before and after irradiation.

After irradiation it is observed that the concentration of phosphate ions decreases from 4.497 to 1.75 mg/l from where a yield of 64.78% for the raw water, and 1.37 to 0.6 mg / l with a yield of 53.28% for treated water.

However, the value recorded at the output of the station continues to conform to limit values of rejection parameters in the receiving environments (<2 mg / l), according to the Official Journal of the Algerian Republic 2006

Effect of Gamma radiation on microbiological parameters

The nature of the microbial population in wastewater is very varied (Rodier, 2005). Bacteria are routinely sought in water, principally as witnesses of faecal contamination (Gaujous, 1995). We are interested in this study essentially to the faecal coliforms and *Escherichia coli* for the following reasons:

Coliforms are ubiquitous and can be found in natural waters. the determination of the total number of coliforms is not generally considered such as a bio-indicator to determine the presence or absence for pathogenic microorganisms, only *Escherichia coli* remains the most reliable indicator to determine the presence or absence of a pollution indicating fecal contamination. Thus, *Escherichia coli* which is an excellent indicator of fecal contamination, and it is much less resistant in the environment or at treatments of disinfection than many pathogenic germs and others indicators of fecal pollution (Conseil Supérieur d'Hygiène Publique de France, 1995).

The bacteriological results are shown in Table 2.

Table 2. Results of microbiological analyzes of treated wastewater from the WWTP Tizi-Ouzou before and after irradiation

Germes Water Type	Before irradiation		After irradiation	
	total coliforms (germes/100ml)	<i>E.Coli</i> (germes/100ml)	total coliforms (germes/100ml)	<i>E.Coli</i> (germes/100ml)
Raw water	45.10 ⁴	36. 10 ⁴	0	0
clarified water	15.10 ³	12.10 ³	0	0

The results obtained before irradiation show a significant presence of total coliforms and *Escherichia coli* in raw and treated water on the various sampling points. The number of total coliforms and *E. coli* in the raw water is respectively 45,10⁴ and 36,10⁴ germs / 100 ml comparing to the treated water which is of 15.10³ and 12.10³ germs / 100ml, ie a purification yield of 66,66%. This result is agreement with those obtained by (Emer *et al*, 2011) and (Block en 1982) who have concluded that the treatment using activated sludge when properly conducted, allows the elimination of approximately 61.99% of Coliform bacteria. After irradiation at the dose of 16 kGy, we have a complete elimination or a yield of 100%, hence the effectiveness of gamma radiation to inhibit the microorganisms that interacts either by direct effect on a sensitive site at the organism (Wang et Wang ,2007), usually deoxyribonucleic acid (DNA) which directs the reproduction and synthesis of cellular components; or indirect way due to the formation of the main products of radiolysis of water and their interactions with cell particles (Emer *et al.*, 2011).

CONCLUSION

In light of this study, we can say that the gamma radiation would be an alternative to the decrease of nitrogen content and phosphorus well as for disinfection of treated sewage. Furthermore, a combination of ionizing radiations with a conventional biological treatment process, could lead to better conservation of natural environments receivers. Finally, the experimental results obtained show that treated wastewater does not present any limit and could be used in several areas such as agriculture for example.

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