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Insinuation *Salmonella Typhi* for ^{23}Na and ^{60}Co Radioactive Sources

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ABSTRACT

The study investigates the effect of radioactive sources on Salmonella typhi, a gram-negative, rod-shaped bacterium that infects various cell types. Salmonella primarily spreads through contaminated food, commonly tainted by human or animal waste. In this descriptive research, 50 S. typhi samples from diverse patients at Baghdad Hospital were utilized. The method involved identifying the bacteria using Viteck2, culturing them on Nutrient broth and Nutrient agar, and exposing them to various radioactive sources: Na23 and CO60 (1 µCi and CO60 10 µCi). Petri dishes containing Nutrient agar were used for sample plating, followed by incubation for 24 hours at 37°C. The results showed that exposure to beta and gamma rays emitted by Na23 at an activity level of 10 µCi resulted in increased radiation levels with time. Without Almmonium, the radiation doses for 1, 2, and 3 hours were 9.64 mSv, 19.29 mSv, and 28.93 mSv, respectively, leading to varying viable cell counts. With Almmonium, the doses for the same periods were significantly lower, with fewer viable cells. Similarly, exposure to CO60 (1 µCi) resulted in varied radiation levels and viable cell counts, indicating a similar trend with and without Almmonium. CO60 (10 µCi) also demonstrated an increase in radiation doses over time, displaying an impact on viable cell counts. The study concludes that radiation emitted from Sodium and Cobalt radioactive sources exhibited effectiveness in eliminating S. typhi in direct proportion to increased exposure time and dose. This research highlights the potential for radioactive sources to impact the viability of Salmonella typhi cells.

KEYWORDS: Radioactive sources, Gamma rays, Beta rays and Inhibition.

الخلاصة

هذه الدراسة تقوم بفحص تأثير المصادر الإشعاعية على السالمونيلا تايفي، وهي بكتيريا معوية متحركة ، سالبة لصبغة الجرام، ذات شكل عصوي لاهوائية اختيارية، غير منتجة للسبورات، وتصيب مجموعة متنوعة من أنواع الخلايا بما في ذلك الخلايا الطلائية ، الجذعية ، والبلعمية. السالمونيلا تنتشر أساسًا من خلال الطعام الملوث، والذي يكون غالبًا ملوثًا بالفضلات البشرية أو الحيوانية. في هذه البحث، تم استخدام ٥٠ عينة من السالمونيلا تايفي من مرضى مختلفين في مستشفى بغداد. تضمنت الطريقة تحديد البكتيريا باستخدام Viteck2، وزراعتها على مرق غذائي وغراء غذائي، ثم تعريضها لمصادر إشعاعية متنوعة: Na23 و CO60 (1 µCi و CO60 10 µCi). استُخدمت أطباق بيتري تحتوي على غراء غذائي لزرع العينات، تلتها فترة حضانة لمدة ٢٤ ساعة عند ٣٧ درجة مئوية. أظهرت النتائج أن التعرض لأشعة بيتا وجاما الناتجة عن Na23 بمستوى نشاط ١٠ µCi أدى إلى زيادة في مستويات الإشعاع مع الزمن. بدون ألمونيوم، كانت جرعات الإشعاع لفترات الساعة الواحدة، والساعتين، والثلاث ساعات ٩,٦٤ ميلي سيفرت، و١٩,٢٩ ميلي سيفرت، و٢٨,٩٣ ميلي سيفرت على التوالي، مما أدى إلى تغير في عدد الخلايا القابلة للنجاة. مع الألمونيوم، كانت الجرعات لنفس الفترات أقل بشكل ملحوظ، مع وجود أقل عدد من الخلايا القابلة للنجاة. بالمثل، أدى التعرض لـ CO60 (1 µCi) إلى مستويات متغيرة من الإشعاع وعدد متغير من الخلايا القابلة للنجاة، مما يشير إلى اتجاه مماثل بوجود أو عدم وجود ألمونيوم. أظهر CO60 (10 µCi) أيضًا زيادة في جرعات الإشعاع مع مرور الوقت، وعرض تأثيرًا على عدد الخلايا القابلة للنجاة. يستنتج البحث أن الإشعاع الناتج عن مصادر الصوديوم والكوبالت كان فعالًا في القضاء على

السالمونيلا تايفي بنسبة مباشرة إلى زيادة وقت التعرض والجرعة. يسلط هذا البحث الضوء على إمكانية تأثير مصادر الإشعاع على قابلية البقاء لخلايا السالمونيلا تايفي.

INTRODUCTION

Salmonella is the name given to a genus of rod-shaped (bacillus), gram-negative, facultatively anaerobic, non-spore producing, motile enterobacteria that belong to the family Enterobacteriaceae [1]. These bacteria are not able to create spores. *Salmonella enterica* and *Salmonella bongori* are the two different species of this type of bacteria. *S. enterica* is the type species, and it can be further subdivided into six different subspecies [2][3], with over 2,600 different serotypes. Daniel Elmer Salmon (1850–1914), an American veterinary surgeon, is honored with the naming of the bacterium Salmonella [4].

Salmonella species are capable of infecting cells from the inside [5][6]. Salmonella is capable of infecting a wide range of cell types, including epithelial cells, dendritic cells, macrophages, and M cells [7]. When oxygen is present in an aerobic environment, Salmonella, a facultative anaerobic bacterium, uses it to produce ATP. However, oxygen is not present in an anaerobic environment. Salmonella generates ATP through the fermentation process by exchanging one or more of the four electron acceptors that are less effective than oxygen at the end of the electron transport chain. These electron acceptors are sulfate, nitrate, sulfur, or fumarate [8].

The vast majority of infections are contracted as a result of consuming food that has been tainted with waste from either humans or animals, such as that which was left behind by a worker in the food service industry at a restaurant. The typhoidal and nontyphoidal serotypes of Salmonella are the two basic categories of this pathogen. Nontyphoidal serotypes are responsible for the majority of cases of gastrointestinal illness, which normally clear up on their own. They are zoonotic, which means that they can be transmitted from humans to other animals and can infect a range of different species of animals. Two typhoidal serotypes that are unique to humans and do not exist in any other species are known as Salmonella Typhi and Salmonella Paratyphi A [9].

AHL transcriptional regulators' unique binding patterns are revealed by molecular modeling and active site study of the SdiA homolog, a potential quorum sensor for Salmonella typhimurium pathogenecity [10]. It is also known that the spvB gene from the Salmonella plasmid increases bacterial pathogenicity by preventing autophagy [11].

It is well known that salmonellosis can result in spondylosis or back discomfort. Infection of the gastrointestinal tract, enteric fever, bacteremia, local infection, and the chronic reservoir state are some of the five clinical patterns it might take. The early signs include a generalized temperature, fatigue, and myalgia, among others [12][13]. When a person has bacteremia, it can spread to any part of the body and cause a localized infection or abscesses. Arthritis, urinary tract infections, central nervous system infections, bone infections, and soft tissue infections are some of the manifestations of localized Salmonella infections. When the reticular endothelial cells' ability to function declines, the infection may become activated and, as a result, travel to the bone several months or even years after the acute form of salmonellosis. Infections can also remain dormant for a long time [14][15].

Ionizing and non-ionizing radiation can be classified by the energy of the particles that are radiated. In order for ionizing radiation to ionize and break chemical bonds, it must carry more than 10eV, because to their vastly differing levels of toxicity, this distinction is critical. Radioactive materials emitting helium nuclei, electrons or positrons, or photons, respectively, are a typical source of ionizing radiation. Radioactive sources are defined as a known quantity of a radionuclide that emits ionizing radiation; gamma rays, alpha particles, beta particles, and neutron radiation are the most frequent types of radiation. One of the most common uses of radioactive sources is in the treatment of target materials, where the radiation acts as an ionizing agent. Cobalt-60 (^{60}Co) is a radioactive isotope of cobalt that was created artificially and has a half-life of 5.2713 years. In

nuclear reactors, it is created artificially and used in various applications, the equation of Cobalt is $^{59}_{27}Co + n \rightarrow {}^{60}_{27}Co \rightarrow {}^{60}_{28}Ni + e^- + \nu e + \gamma$ rays. From ^{18}Na through ^{39}Na, there are 21 known isotopes of sodium (^{11}Na), as well as the two isomers (^{22}Na and ^{24}Na). ^{23}Na is the only isotope that is both stable and primordial. As it turns out, sodium possesses two radioactive cosmogenic isotopes: ^{22}Na and ^{24}Na, both with half-lives of about 15 hours. All other isotopes have half-lives of less than a minute, with the exception of those two. A half-life of $1.3(4) \times 10^{-21}$ seconds makes ^{18}Na the fastest-acting [16].

MATERIALS AND METHODS

Study Design

Cross-sectional study design depending in this research for descriptive study design.

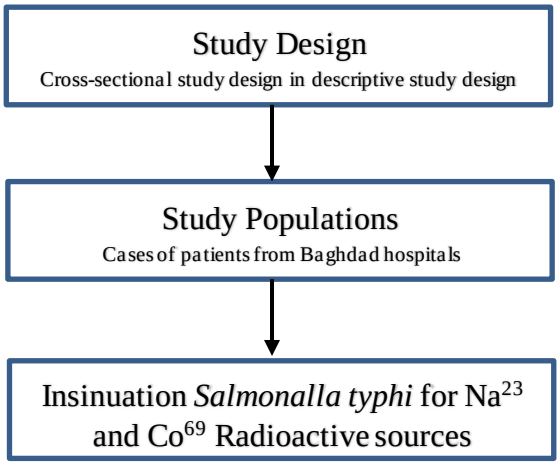

Figure 1. Scheme of study design of this research.

Study populations and Bacterial isolates

A total of summation of sample Salmonella typhi strain were raised from patients who were admitted in Baghdad infirmary in 2022 that identification via conventional biochemical responses depending [17].

Insinuation Salmonella Typhi for Na23 and Co60 Radioactive Sources

Salmonella typhi implanted was accomplished depending to [18] with several alterations, implanted in Nutrient broth at 37° C for 24 hrs, then centrifuged at 5000 rpm till 10 minutes. The pellet was suspended of sterile normal saline and rapprochement with MacCfrland 0.5, subsequently exposition 1 ml of suspension to Nd:YAG laser with comparison of control group (without exposure to radiance), each run was done in triplicate and injected in Trypton soy agar. The neutralization of proportion of assassination is computed by Eq. (1):

$$\text{Proportion of assassination } \% = \frac{\text{Control} - \text{treated}}{\text{Control}} * 100 \quad (1)$$

RESULTS AND DISCUSSIONS

Study Design

Cross-sectional study design in Analytical study design by 50 isolates from patients have *S. typhi*.

Study Populations and Bacterial Isolates

Outcomes of combination of sample are 50 of *S. typhi* of patient human.

Impact of Radioactive Sources of S. Typhi

S. typhi exhibition to Na23 (10µCi), CO60 (1 µci) and CO60 (10 µci), implanted on petridishes plates of Nutrient agar incubated in the incubator for 24 hrs. at 37°C.

The results of exposure beta and gamma rays emitted by Na23 activity 10 µCi, without Aluminum in dose D (1hr.) = 9.6425396497 mSv; D (2hr.) =19.2850792994 mSv; D (3hr.) = 28.9276189491 mSv for (1, 2, 3) hrs. with viable cell (26, 51, 0) respectively and with Aluminum in dose D (1hr.) = 0.01528854 mSv; D (2hr.) =0.03057708 mSv; D (3hr.) = 0.04586562 mSv for (1, 2, 3) hrs. with viable cell (0, 2, 1) respectively. In addition, exposure to CO60 (1 µCi) with Aluminum in dose D (1hr.) = 0.34735529*10-2 mSV; D (2hr.) =0.694710586*10-2 mSV; D (3hr.) = 1,042065879*10-2 mSv for (1, 2, 3) hrs. with viable cell (70, 3, 0) respectively and without Aluminum in dose D (1hr.) =12.4667424 mSv; D (2hr.) =24.93348494 mSv; D (3hr.) =37.40022741 mSv for (1, 2, 3) hrs. with viable cell (12, 0,8) respectively.

Table 1. Number of viable cells after exposure to different radioactive sources including Na^{23} with activity 10 µci, Co^{60} with activity 10 µci Co^{60} with activity 1 µci.

No.	Radioactive sources	Activity (µci)	Viable cell in 1 hr.	Viable cell in 2 hr.	Viable cell in 3 hr.
1	Na ^{23} Without Almmonium	10	26	51	0
	Na ^{23} With Almmonium		0	2	1
2	Co ^{60} Without Almmonium	1	70	3	0
	Co ^{60} With Almmonium		12	0	8
3	Co ^{60} Without Almmonium	10	66	6	18
	Co ^{60} With Almmonium		0	0	0

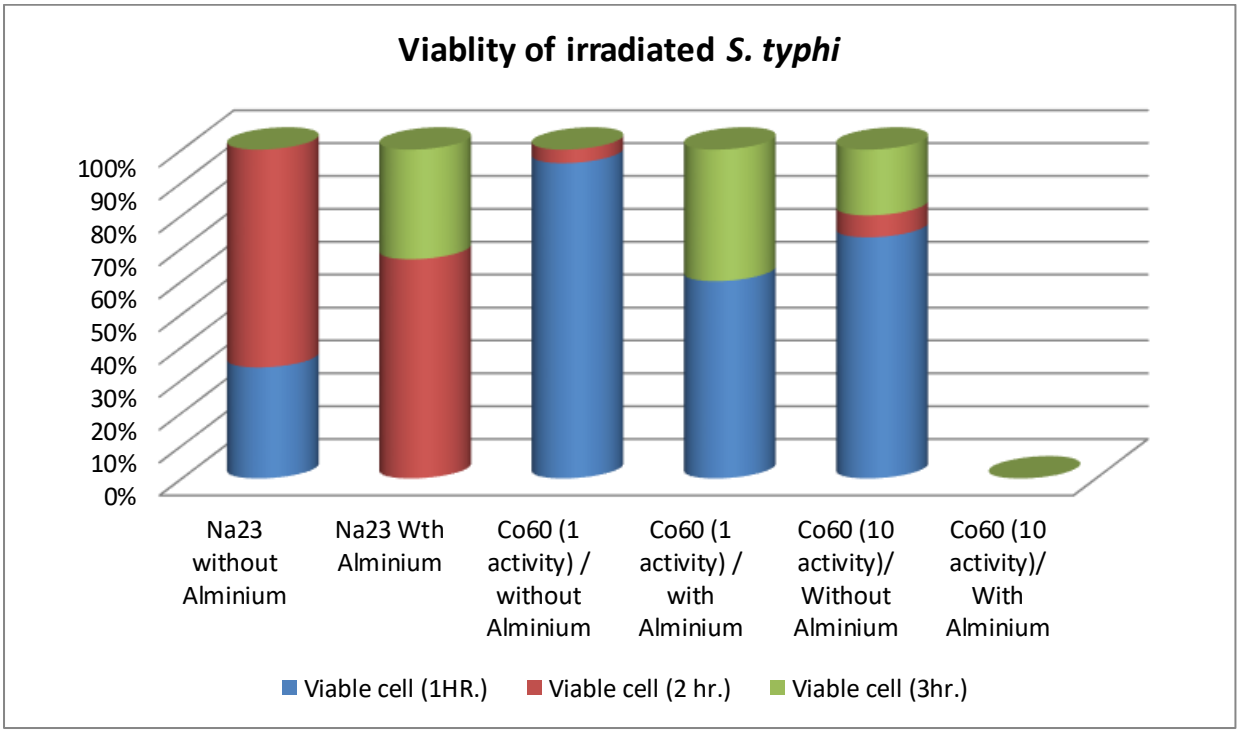

Figure 2. Viable cells of irradiated *S. typhi* after exposure to Na^{23} (10 µCi), Co^{60} (10 µCi) and Co^{60} (1 µCi) on Nutrient agar.

Another exposure to CO60 (10 µCi) without Aluminum in dose D (1hr.) = 1.86870209 mSV; D (2hr.) =3.73740418 mSv; D (3hr.) = 5.60610627 mSV for (1, 2, 3) hrs. with viable cell (66,6,18) respectively and with Aluminum in dose D (1hr.) =0.23348838*10-5 mSv; D (2hr.) =0.466977476*10-5 mSv; D (3hr.) = 0.700466214*10-5 mSv for (1, 2, 3) hrs. with viable cell (0, 0,0) respectively.

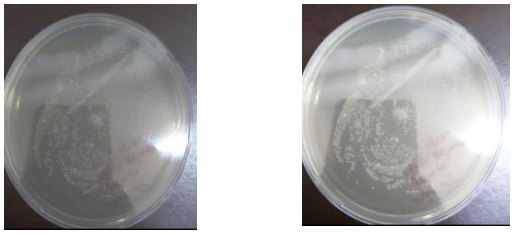

Figure 3. Irradiated S. typhi viable cells after exposure to Na23, Co60.

In a previous study by [19], cobalt toxicity in Escherichia coli caused by high cobalt concentrations was explained by competition between cobalt and iron in several metabolic processes, including the formation of free radicals and the reduction of the free thiol pool. The cobalt protoporphyrin IX (CoPPIX) that was produced as a result of higher cobalt concentrations in the culture medium was integrated into heme proteins, such as membrane-bound cytochromes and an expressed human cystathionine beta-synthase (CBS), in this article. The ability of cytochromes to transport electrons was blocked by CoPPIX, which significantly reduced respiration. Bacterial cells adjusted their mixed acid fermentative pathway during aerobiosis in order to adapt to the elevated cobalt concentration. We took advantage of *E. coli's* capacity to introduce cobalt into PPIX in order to create heme proteins that were CoPPIX replaced. The number of cell passes in a cobalt-containing media led to a rise in the level of CoPPIX-substitution. When compared to in vivo replacement with metalloporphyrin heme analogs or in vitro enzyme reconstitution, this method is less expensive to synthesize cobalt-substituted heme proteins, and it appears to be especially appropriate for complex heme proteins containing an extra cofactor, such as human CBS. Endophytic bacteria and fungi colonize plants that thrive in diverse terrestrial and aquatic environment types, according to results of a different study by [20]. under our study, we look at the populations of endophytic bacteria and fungi living on the halophyte Kalidium schrenkianum under radiation-stressed environments. The geochemical elements and radiation (at low, medium, high, and control levels) had an impact on the endophytic communities' structure. In the endophytic communities of K. schrenkianum, the bacterial class Actinobacteria and the fungal class Dothideomycetes were dominant. While the roots of K. schrenkianum showed more bacterial diversity, the aerial tissues displayed higher fungal diversity. There was no discernible impact of radiation on the diversity of bacterial classes. The variety of root endophytes was significantly influenced by the soil's pH, total nitrogen content, and organic matter. Radiation had a significant impact on fungal co-occurrence networks and had an impact on bacterial and fungus community structure in roots but not in aerial tissues. Overall, endophytic bacterial and fungal genetic diversity was higher in radioactive environments; however, endophytic bacterial and fungal diversity in the plant showed negative associations. In radioactive conditions, both endophytic bacteria and fungi had more genetic diversity. Our research suggests that radiation has an impact on root endophytes and that the endophytes connected to K. schrenkianum's aerial tissues and roots adhere to various community-building processes and stress-response paradigms.

CONCLUSIONS

The most effective radiation for eliminating S. typhii, using Na23 without ammonium in an activity of 10 µCi for a duration of 3 hours, resulted in a dose D= 28.9276189491 mSv with no viable cells present. When employing Na23 with ammonium at the same activity level, the dose for 1 hour was D=0.01528854 mSv with no viable cells. CO60 exposure at an activity of 1 µCi with ammonium led to a dose of D=1,042065879*10-2 mSv for 3 hours without viable cells. Similarly, CO60 without ammonium at 1 µCi resulted in a dose of D=24.93348494 mSv for 2 hours with no viable cells. Another exposure to CO60 at an activity of 10 µCi without ammonium led to a dose of D=3.73740418 mSv for 2 hours with 6 viable cells. Lastly, CO60 with ammonium at an activity of 10 µCi resulted in a dose of D=0.23348838*10-5 mSv for 1 hour with no viable cells. Radiation emitted from both Sodium and Cobalt sources proved effective in progressively eliminating S. typhi, displaying efficacy with escalating doses and exposure times.

Disclosure and Conflicts of Interest: The authors advertise that they have no conflicts of interest.

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