Statistical Treatment of the Gamma-Ray Spectrum Using the Language Programming R

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Abstract

In this work we use the laws of statistics and statistical distributions software to try to understand the random statistical nature of the dissolution of gamma rays and their interaction with the material by studying the spectrum regions of the sodium-22 spectrum using the statistical programming language R. such Normality test, Anova Test as well as Pearson correlation coefficient test and the linear Regression test and we were found that there is no strong statistical relationship between the random variables studied using linear regression, also it was found that the average mean of the standard samples follows the normal distribution and this was confirmed by using the T-test, there is also a slight difference between the sampling random mean and the standard mean for the same samples using the same statistical distribution.

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Introduction

Radioactive decay is a random process, in addition as the interaction of a gamma ray with matter is follow the laws of probability, that is, under certain conditions such as the spectrum of gamma ray photons or the atomic number with which the interaction occurs [1], the possibilities are different for the photoelectric effect, the Compton scattering, or the pair production, so thus subject to the laws Statistics [2]. So, the radiation emitted from nuclear decay is subject to a certain degree of statistical variability. These inherent fluctuations represent an inevitable source of uncertainty in all nuclear measurements and often they can be the predominant source of inaccuracy or error So we used programming and statistical tests to study the spectrum of the sodium -22 source. We analyzed the spectrum areas from the total area of the spectrum, photopeak, and others by using the statistical programming language R.[3] The R statistical program is one of the most popular statistical programs. This program language is similar to the S programming language that was developed in Bell Lab[4].

R Studio is an operating environment for r statistical software with a range of wonderfully designed windows and tools that help manage the programming session in a structured manner that helps increase productivity and creativity. The use of such a program does not require a different programming language than R [5].

Experimental Methods

An electronic counting and analysis system was used by using NaI (Tl) sodium iodide crystal detector with size (3 "x 3") cm was measured based on the high penetration strength of the gamma ray in the materials by, the equipped by a company (Spectrum Techniques LLC), the nuclear measurements and analysis were done a computer program called UCS_30.

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The UCS30 ADVANCED Spectrometer System contain 4096 channel MCA with internal preamplifier, high voltage (0-2048V), upper and lower-level discriminators and multichannel scaling for half-life and decay studied. [6]. Figure 1: shows Nuclear counting system NaI(Tl) in present study radiation detector (NaI(Tl) scintillation counter) is a pulses of light produced in a transparent material by the passage of a particle [7].
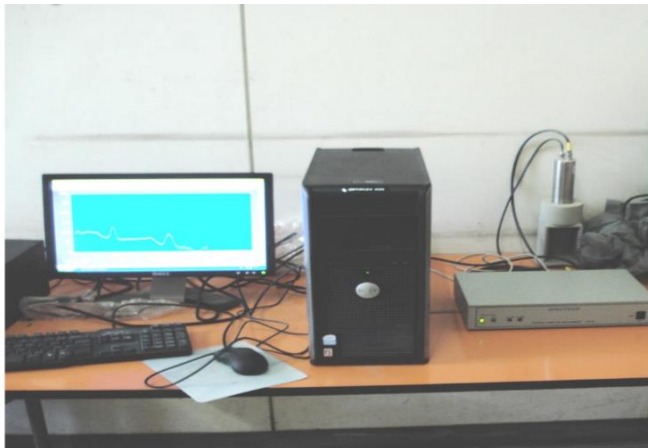

Figure 1. Nuclear detection system: NaI(Tl)

The iodine provides most of the stopping power in sodium iodide. These crystalline scintillators are characterized by high density, high atomic number, its efficiency and the high precision and counting rates are a consequence of the extremely short duration of the light flashes, from about 10^{-9} to 10^{-6} sec, that are possible and pulse decay times of approximately (1 μsec). Scintillation exhibit high efficiency for detection of gamma rays and are capable of handling high count rates. [8].

In general, a scintillation detector consists of:

Scintillator. A scintillator generates photons in response to incident radiation.

Photodetector. A sensitive photodetector which converts the light to electrical signal and electronics to process this signal. [9].

scintillation counters can be used to determine the energy, as well as the number, of the exciting particles (or gamma photons). For gamma spectrometry, the most common detectors include sodium iodide (NaI) scintillation counters and high-purity germanium detectors. [10].

Most scintillation detectors are only sensitive to one type of radiation. So NaI detectors will pick up gamma radiation, but not alpha or beta. every time a gamma hits the crystal it the NaI detectors for is identifying specific radionuclides by measuring the energy of each individual gamma that enters the crystal this process is called gamma spectroscopy, or can also be called multi-channel analysis (MCA).

The basic principle behind gamma spectroscopy is that every gamma-emitting radionuclide emits a gamma ray (or a few gammas) with very specific energies and if we can identify the gamma energies precisely enough then we can identify the radionuclide(s) present. so, sodium-22 (^{22}Na) gives off a gamma peak at 1.274 (MeV) as Figure (2). [11]
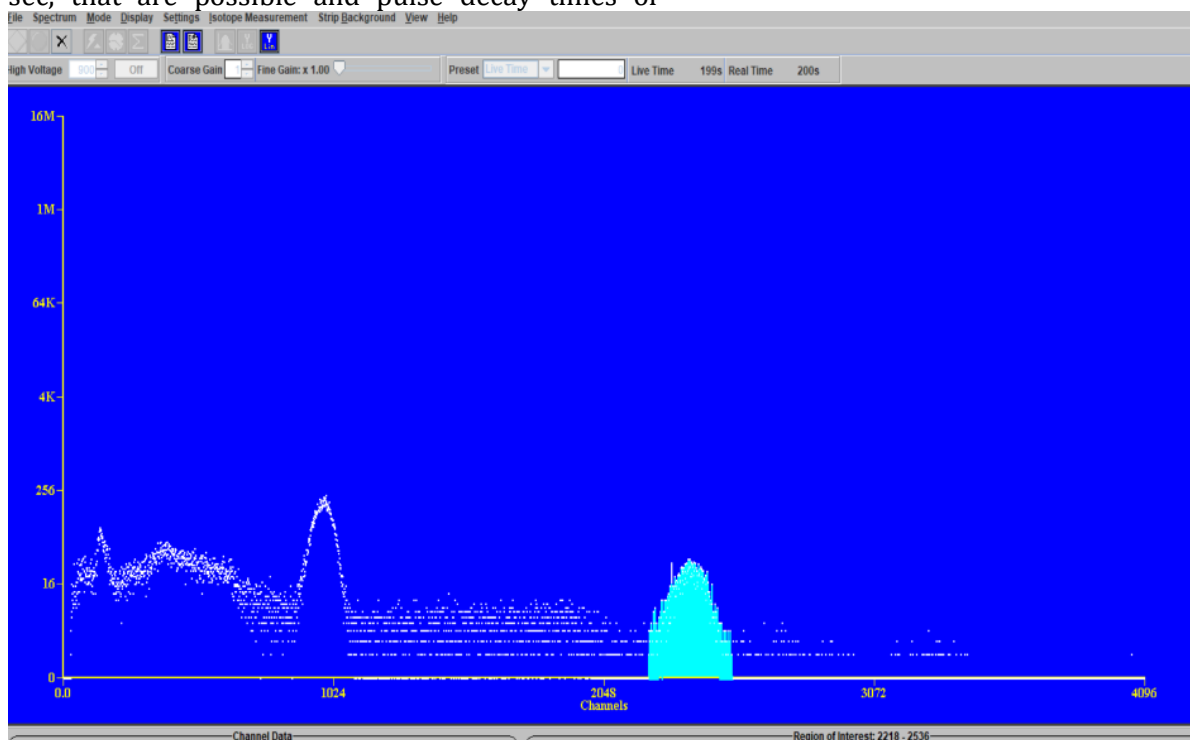
Figure 2. Spectrum Sodium-22.

The spectrum produced by the emission of these photons has a single photopeak. Two hundred readings gathered. The sodium spectrum and the collection time of each spectrum is (200 sec) with the voltage 900 volt and 4096 channel and the distance is (7cm) between the radioactive source and the detector.

Theoretical Part

Random variable is a variable that represents the numerical results of a random phenomenon. The random variable must be measurable. There are two types of random variables:

First: (discrete random variable) such as binomial distribution. It can be described as a probability mass function that is represented by a function[12]
$$F(X)=P(X=X) \qquad (1)$$
Where it represents the probability of taking the random variable X Value with x. Its characteristics include:

a) $F(X_i) \geq 0$, for $i=1,...,n$.
b) $\sum_{i=1}^{N} F(X_i)=1$ \qquad (2)

Second: (continuous random variable) such as Normal distribution and Exponential distribution. It can be described as a probability density function that is represented by a function.[11]
$$f(x)=P(X=x) \qquad (3)$$
Where it represents the probability of taking the random variable X Value with x. Its characteristics include:

a) $f(X_i) \geq 0$, for $i=1,...,n$.
b $\int_{-\infty}^{\infty} \llbracket f(x....... ...... \qquad (4)$

Single Contrast Test (One-Way ANOVA Test) in R-R Programming Language

One-Way ANOVA Test is a statistical method used to show the difference between two or more averages by analyzing the difference within and between different categories. It is mathematically described as follows[13] :
$$H_0=X \sim N(\mu,\sigma^2) \text{ or } H_1=X \neq N(\mu,\sigma^2) \qquad (5)$$
Also
$$H_0: \sigma_1^2=\sigma_2^2=\cdots=\sigma_r^2$$
$$\text{or } H_1: \sigma_i^2 \neq \sigma_j^2 \text{ for some} \qquad (6)$$

Linear Decline using R Programming Language

Linear regression is a statistical method that aims to create a linear relationship between dependent variable and independent variables, as well as to predict (prediction) of the values of the dependent variable. The linear decline can be defined mathematically as follows[14] :
$$y=\alpha+\beta_1 x_1+\beta_2 x_2+....+\beta_p x_p+\epsilon) \qquad (7)$$
where it's called y dependent variable, response variable, outcome variable, also called $x_1,x_2,...,x_p$ Independent variables, explanatory variables, or predictor variables. Residuals are defined as the difference between the observed (actual) value of the child variable and the child variable value that is predicted using the regression line.[15]

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Results

In this paper, the radioactive nature of the [22]Na source was studied spectrum areas where the net total area was measured in addition to the two net photopeak spectrum of the sodium-22 as shown in Table.

Table 1. 22Na spectrum

sample	Total Area		Photopeak 1		Photopeak 2		sample	Total Area		Photopeak 1		Photopeak 2	
	Net	Cross	Net	Cross	Net	Cross		Net	Cross	Net	Cross	Net	Cross
1	41,281	43,228	13,392	15,274	2,697	3,395	101	39,431	43,362	14,608	15,460	2,936	3,520
2	36,893	43,694	14,100	15,519	2,957	3,446	102	31,208	43,340	13,730	15,312	3,310	3,604
3	35,222	43,149	12,689	15,120	2,833	3,437	103	41,732	43,427	14,128	15,494	2,844	3,590
4	31,263	43,333	14,087	15,461	3,030	3,402	104	32,574	43,009	13,840	15,120	3,183	3,499
5	35,567	43,318	13,533	15,274	2,993	3,505	105	41,449	43,395	13,741	15,349	2,850	3,476
6	31,188	43,348	13,923	15,140	3,136	3,412	106	34,838	43,349	14,160	15,484	2,931	3,486
7	39,330	43,396	13,904	15,369	2,930	3,468	107	27,434	43,608	14,689	15,436	3,091	3,571
8	36,314	43,335	13,800	15,511	2,802	3,436	108	39,549	43,174	13,829	15,423	2,899	3,431
9	40,211	43,640	13,662	15,202	2,871	3,384	109	41,361	43,260	13,783	15,224	2,904	3,453
10	38,150	43,338	13,430	15,321	2,881	3,406	110	26,069	43,145	13,519	15,140	2,943	3,535
11	29,105	43,083	13,826	15,200	3,108	3,511	111	41,388	43,215	13,919	15,476	2,921	3,459
12	33,924	43,338	13,760	15,248	3,264	3,548	112	31,654	43,022	13,772	15,233	2,979	3,382
13	33,287	42,933	13,840	15,353	2,626	3,222	113	31,542	43,620	13,503	15,451	3,291	3,581
14	31,191	43,279	13,697	15,291	2,673	3,489	114	36,385	43,066	13,296	15,007	2,760	3,431
15	35,869	43,444	14,064	15,367	2,803	3,555	115	22,593	43,351	13,642	15,328	3,283	3,561
16	25,856	43,515	13,807	15,272	2,911	3,437	116	32,999	43,155	13,538	15,132	2,889	3,378
17	41,610	43,519	13,812	15,343	2,768	3,439	117	32,967	43,234	14,048	15,165	3,079	3,469
18	37,426	43,241	13,747	15,380	2,452	3,454	118	32,799	43,243	13,939	15,290	3,255	3,538
19	30,207	43,669	13,767	15,400	3,208	3,647	119	35,175	43,283	13,623	15,207	2,889	3,540
20	41,262	42,965	13,940	14,964	2,727	3,376	120	33,408	43,151	13,689	15,178	3,153	3,441
21	31,502	43,680	13,547	15,318	2,578	3,518	121	41,432	43,341	14,096	15,248	2,500	3,366
22	27,873	42,163	13,540	14,957	2,783	3,268	122	33,566	42,770	12,901	14,801	3,082	3,511

23	26,430	43,945	14,600	15,557	3,225	3,492	123	33,473	43,554	13,362	15,244	3,320	3,449
24	37,793	43,497	13,427	15,168	3,185	3,469	124	33,175	43,388	13,496	15,359	3,126	3,393
25	32,094	43,633	13,426	15,374	3,293	3,565	125	27,070	43,325	12,837	14,980	2,680	3,514
26	30,635	43,425	13,894	15,224	2,835	3,551	126	41,169	43,201	14,376	15,229	3,078	3,357
27	31,649	43,488	13,688	15,110	3,042	3,471	127	33,763	43,379	13,745	15,418	2,949	3,439
28	27,341	43,266	14,452	15,317	2,957	3,329	128	30,295	43,243	13,377	15,178	2,729	3,370
29	33,331	43,277	13,731	15,196	2,659	3,382	129	35,712	43,261	14,007	15,070	2,713	3,473
30	24,689	43,474	13,814	15,327	2,890	3,416	130	35,816	42,971	13,308	14,962	2,736	3,482
31	36,421	43,204	13,552	14,982	2,982	3,555	131	39,696	43,089	13,477	15,188	3,092	3,495
32	33,398	43,337	18,389	15,100	3,399	3,539	132	37,599	43,213	13,701	15,283	3,072	3,507
33	38,110	43,244	13,798	15,311	3,115	3,523	133	29,182	43,274	13,544	15,177	2,650	3,447
34	37,369	43,279	14,294	15,330	2,963	3,476	134	33,327	43,197	13,781	15,150	3,043	3,437
35	34,850	43,361	13,552	15,203	2,772	3,451	135	25,634	43,374	13,236	15,131	2,660	3,502
36	35,567	43,272	13,857	15,370	3,250	3,529	136	30,257	43,278	14,146	15,169	2,979	3,529
37	41,605	43,568	14,341	15,512	2,726	3,485	137	35,609	42,996	14,317	15,278	3,069	3,454
38	31,324	43,169	13,720	15,071	2,736	3,496	138	25,649	43,434	13,626	15,337	2,887	3,566
39	31,757	43,548	13,760	15,489	2,652	3,457	139	22,589	42,855	13,807	15,226	2,568	3,372
40	33,567	43,176	13,053	15,154	2,853	3,509	140	41,093	43,050	13,659	15,190	2,809	3,363
41	31,523	43,530	13,853	15,318	2,839	3,480	141	41,650	43,577	14,297	15,579	2,900	3,294
42	39,505	42,912	13,926	15,334	2,844	3,405	142	39,692	43,148	13,509	15,370	3,024	3,303
43	36,243	43,021	13,992	15,277	3,023	3,462	143	41,337	43,369	13,545	15,102	2,720	3,399
44	33,508	43,634	14,086	15,389	2,853	3,442	144	37,418	42,936	13,619	15,084	3,100	3,503
45	39,233	43,284	13,722	15,379	3,034	3,401	145	34,996	43,295	13,535	15,426	3,295	3,435
46	34,884	43,400	12,995	15,120	2,948	3,455	146	32,479	42,881	13,774	15,169	2,903	3,434
47	33,411	43,447	14,205	15,357	3,338	3,476	147	41,723	43,372	13,761	15,154	3,271	3,565
48	33,505	43,309	13,792	15,233	2,878	3,647	148	30,782	43,424	14,087	15,746	2,975	3,474
49	34,789	43,396	13,261	15,194	3,077	3,485	149	25,227	43,077	13,979	15,228	2,819	3,483
50	33,391	43,565	14,165	15,489	2.774	3,483	150	32,479	43,208	14,233	15,385	3,148	3,429
51	33,405	43,448	13,223	14,988	3,056	3,473	151	33,443	43,277	13,995	15,164	2,860	3,385
52	35,623	43,532	14,046	15,370	2,962	3,529	152	32,218	43,307	14,114	15,436	3,045	3,466
53	33,305	43,596	13,787	15,207	3,338	3,481	153	41,369	43,350	13,730	15,221	2,916	3,412
54	41,469	43,411	12,993	15,046	3,356	3,499	154	41,503	43,264	14,398	15,437	2,904	3,471
55	38,048	43,368	13,810	15,184	3,235	3,683	155	41,549	43,285	14,027	15,311	3,211	3,481
56	39,863	43,217	13,842	15,475	3,182	3,462	156	30,755	42,852	13,858	15,266	3,037	3,481
57	41,361	43,017	14,228	15,399	2,680	3,359	157	36,656	43,373	13,714	15,389	3,154	3,590
58	35,131	43,402	14,488	15,464	2,637	3,405	158	28,861	42,932	14,333	15,324	2,282	3,331
59	25,896	43,420	14,276	15,485	3,111	3,527	159	29,142	43,270	13,284	15,238	2,839	3,443
60	34,450	43,270	14,092	15,436	2,934	3,453	160	33,309	43,075	13,993	15,184	2,437	3,335
61	39,864	43,214	13,616	15,147	2,419	3,295	161	32,711	43,227	13,638	15,349	3,176	3,496
62	32,137	43,703	13,623	15,220	2,923	3,423	162	34,808	43,169	13,806	15,204	3,005	3,413
63	37,320	43,239	13,214	15,231	2,415	3,344	163	34,890	42,825	13,231	15,032	3,047	3,466
64	39,336	43,389	14,179	15,389	3,161	3,443	164	33,870	43,081	13,667	15,350	2,941	3,478
65	34,050	43,014	13,340	15,026	2,959	3,543	165	29,796	43,241	13,469	15,237	3,118	3,512
66	35,492	43,119	13,914	15,217	3,001	3,550	166	33,695	43,244	14,189	15,342	2,877	3,445
67	35,628	43,291	14,053	15,494	2,808	3,464	167	35,660	43,311	14,551	15,344	3,205	3,488
68	33,579	43,465	13,834	15,518	2,855	3,397	168	36,240	43,071	13,742	15,255	3,229	3,522
69	35,632	43,241	13,564	15,044	2,870	3,396	169	34,666	43,243	14,027	15,180	2,820	3,652
70	34,365	43,681	13,642	15,293	3,041	3,531	170	41,273	43,166	13,872	15,407	3,212	3,503
71	34,337	42,944	13,514	15,023	3,038	3,438	171	41,085	43,039	13,826	15,129	3,170	3,440
72	38,066	43,230	13,823	15,312	3,291	3,560	172	29,550	43,446	13,830	15,333	3,102	3,541
73	35,925	43,630	13,491	15,262	2,561	3,303	173	42,000	43,668	13,922	15,483	3,149	3,429
74	37,526	43,496	13,829	15,090	3,136	3,571	174	26,893	43,154	13,795	15,056	3,251	3,547
75	33,864	43,330	13,654	15,236	2,992	3,386	175	31,353	43,161	13,566	15,146	2,781	3,415
76	39,188	43,020	14,688	15,481	2,780	3,407	176	33,016	43,142	13,655	15,144	3,054	3,640
77	41,327	43,283	14,471	15,561	2,939	3,459	177	33,436	43,344	14,698	15,605	3,100	3,382
78	36,532	43,327	13,690	15,197	3,260	3,553	178	33,116	43,017	13,695	15,081	2,870	3,419
79	29,681	43,089	13,725	15,054	3,251	3,558	179	33,070	43,181	14,334	15,433	3,005	3,413
80	29,336	43,019	13,490	15,219	3,209	3,496	180	36,285	43,099	13,221	15,084	2,706	3,317
81	41,722	43,366	14,318	15,399	3,172	3,423	181	33,164	43,313	13,881	15,461	2,625	3,440
82	39,307	43,376	14,174	15,345	2,811	3,497	182	30,989	43,331	14,076	15,286	2,747	3,553
83	41,335	43,081	13,820	15,123	2,683	3,451	183	39,140	42,726	13,782	15,088	3,158	3,442
84	39,473	43,282	14,315	15,468	3,169	3,462	184	31,172	43,276	13,582	15,023	2,903	3,452
85	41,343	43,362	13,571	15,300	3,161	3,459	185	34,759	42,566	13,683	15,079	3,143	3,421
86	38,365	43,367	14,047	15,329	2,862	3,398	186	26,639	43,448	13,884	15,258	2,774	3,430
87	37,557	42,897	14,036	15,464	3,211	3,497	187	33,283	43,012	13,971	15,337	2,940	3,471
88	31,510	43,328	13,209	15,069	3,118	3,494	188	26,701	43,387	14,263	15,370	2,791	3,517
89	35,195	43,194	13,614	15,354	3,381	3,539	189	37,224	42,697	13,566	15,123	2,611	3,417
90	39,893	43,298	14,617	15,860	3,241	3,388	190	39,502	43,322	13,964	15,405	2,705	3,376
91	41,493	43,245	13,372	15,053	3,355	3,502	191	33,008	42,969	13,584	15,090	3,030	3,442
92	32,166	43,291	13,513	15,194	2,933	3,448	192	39,397	43,174	13,566	15,364	3,103	3,532
93	39,912	43,223	13,781	15,492	2,983	3,395	193	35,474	43,395	13,821	15,330	2,721	3,841
94	28,049	43,182	13,688	15,309	2,708	3,334	194	27,855	43,468	14,347	15,293	3,055	3,481
95	33,295	43,279	13,632	15,241	2,927	3,471	195	31,169	43,095	13,701	15,142	2,433	3,394
96	41,155	43,073	13,907	15,273	2,701	3,472	196	31,718	43,221	13,497	15,064	3,282	3,554
97	31,633	43,335	13,644	15,151	3,272	3,554	197	31,608	43,444	14,357	15,414	3,261	3,547
98	41,198	42,961	13,665	15,130	2,697	3,539	198	41,030	42,929	13,459	15,014	2,926	3,433
99	33,319	43,304	13,870	15,080	2,889	3,421	199	34,598	42,897	13,739	15,090	3,128	3,433
100	40,922	42,881	13,915	15,200	2,979	3,373	200	23,032	42,818	13,671	15,202	3,048	3,442

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Table 1 shows the spectrum areas of the radioactive sodium source, where 200 spectra were taken at a time of 300 seconds, an operating voltage of 900 volts, and amplification 1. The table was divided into two parts, each section containing 100 spectra in order to reduce the size of the table.

where: Net is indicates to the net area peak, This table was abbreviated in Table 2.

Table 2. summary spectrum 22Na

summary	Total.Net	Photo.1Net	Photo2Net
Min	22589	12689	2.774
Max	42000	18389	3399.000
Mean	34706	13823	2946.144
Median	34524	13782	2957.000
1st Qu	31653	13579	2810.500
3rd Qu	38559	14027	3130.000
IQR	6906	448	319.5
μ	34705.78	13823.34	2946.144
Var	21294226	231988.6	92795.14
σ	4614.567	481.652	304.6229
Mean (sam.)	34566.26	13837.41	2945.475
Sd (s)	4644.406	503.0848	321.2496
X.bar	34693	13824.54	2945.777
sd (bar)	143.9067	14.47532	9.869021
range	22589 42000	12689 18389	2.774 3399.000

Table.2 shows a summary for sodium spectrum, where : **Total.Net** refer to the net total area of the spectrum, **Photo.1Net** and **Photo.2Net** refers to the Net area for photopeak, and min and Max are refers to values sample in small and large value respectively, also **IQR** is the inter-quartile **range** which is the distance between the third quartile an account of the first **1st Qu** quarter and the third quarter **3rd Qu** of the data and **μ** refer to mean for population value, var is the variance to sample, **σ** is the variance to population, **X.bar** is standard mean, **sd** is the standard deviation and, as Figures from (3-1).

Statistical Analysis

The Figures 3 and 4 gives a summary of the statistical distributions on the studied environment samples, where is Figures 3 a histogram that shows the graphical relationship between the frequency of the sample and the mean of the spectrum. and the Figure 4 is the boxplot of total Area of spectrum and Photopeak Area.

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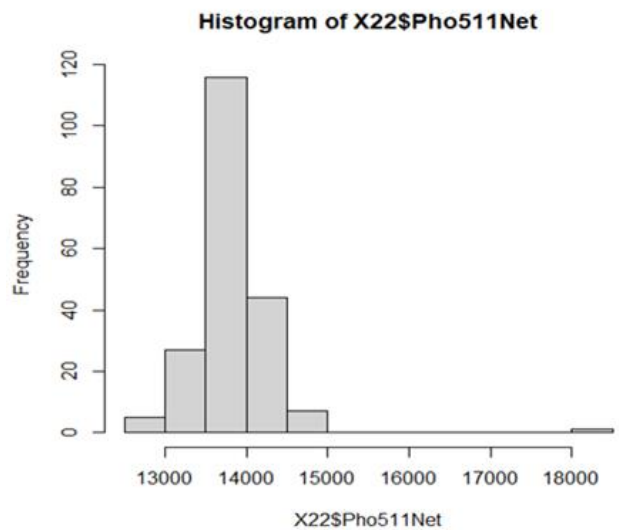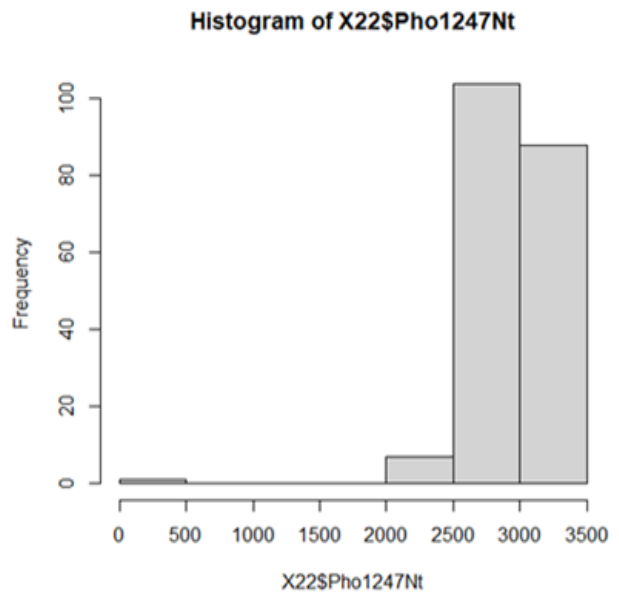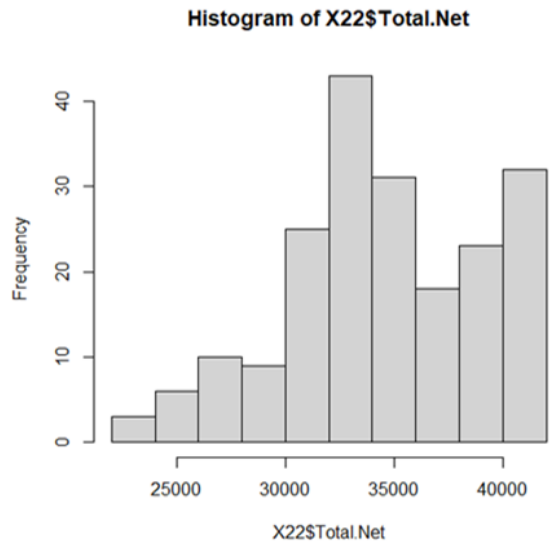
Figure 3. A- Histogram between the data (frequency) Total Net Area
B- Histogram between the data Photopeak 1 Net Area
C- Histogram between the data Photopeak 2 Net Area

The histogram A represents the net area of the total spectrum on the x-axis, and the data on the y-axis, where we notice its difference from figures B and C, which shows the net area of the two photopeaks of the sodium source, where figure C has fewer columns compared to figures A and B, we can the histogram is based on estimating the distribution and spread of the data around the mean, and we note the division of the x-axis with equal periods, and the height of each square represents the number of observations that fall within the mean.
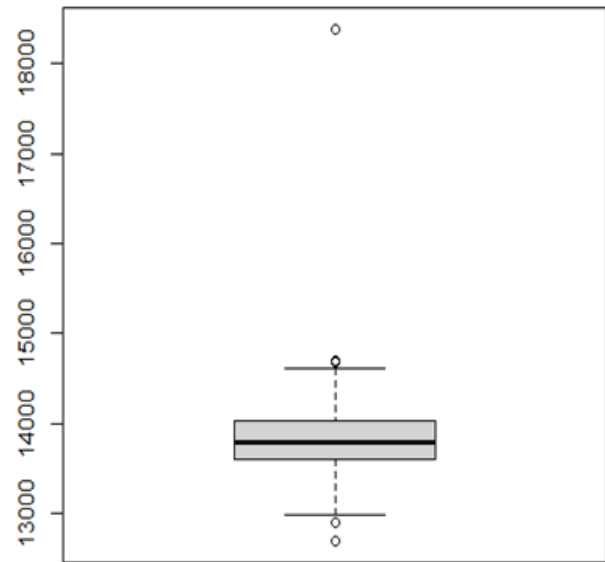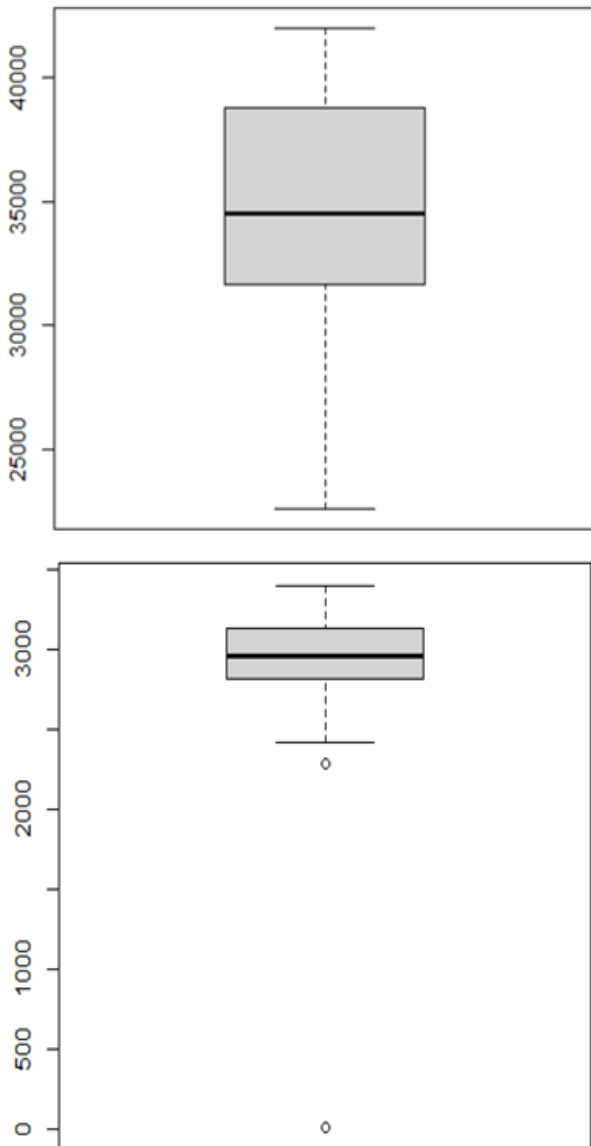
Figure 4. A- boxplot of Total Area of spectrum and Photopeak Area
B- boxplot of Photopeak 1 Net Area
C- boxplot of Photopeak 2 Net Area

Figure 4 displays the diagram, which provides a clear and comprehensive picture of the distribution of data and consists of five values: the smallest value, the first quartile, the third quartile, and the largest value. Where about 50% of the data are collected in the box, as for the rest of the values, they are distributed between the lowest and the highest value, and the broad black line represents the median (the second quarter), and we notice a clear difference between the three shapes and this is evidence of the difference in the spread of data around the mean.

To find out the homogeneity of the variance we use Normality Test or the Kolmogorov-Smirnov test, shapiro. test, and Q-Q. norm for the data samples as table 3.

Table 3. Test of Normality

Type of test	Tota.Net			Phot1Net			Phot2Net		
	X21	X21.samp	X21.bar	X22	X22.samp	X22.bar	X23	X23.samp	X23.bar
Kolmogorov-Smirnov test	2.2e-16	0.1045	0.8528	2.2e-16	0.009215	0.239	2.2e-16	0.05621	0.0743
shapiro.test	4.62e-05	4.627e-05	0.4518	2.2e-16	2.2e-16	0.00223	2.2e-16	2.2e-16	5.954e-05

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Table 3 shows the normality test that shows whether the data follows to a normal distribution or not, so we note p.value if it is greater than (0.05) it is obey to the normal distribution (or take H0), and if it is less than 0.05, it is not obey to the normal distribution (or take H1), as shown in (Eq.5).

where (X21, X22, X23) refers to data in population, (X21.samp, X22.samp, X23.samp) refer to data at random sampling and X21.bar, X22.bar, X23.bar) indicate to standard sample data.

In Shapiro's test, we note that all data are not subject to a normal distribution depending on the p. value. except for the standard samples at Tota.Net and Phot1Net, we notice that it differs from the rest of the data in that it is obey to a normal distribution. because it is standard sampling.

Q.Q. Normal Test

Normal Q-Q Plot

Normal Q-Q Plot
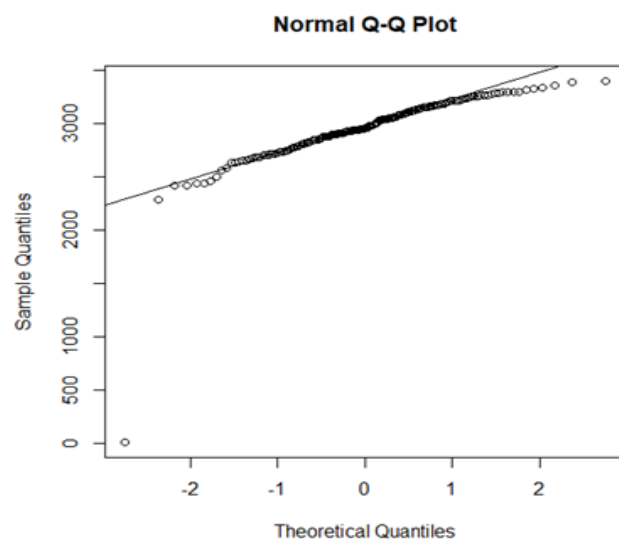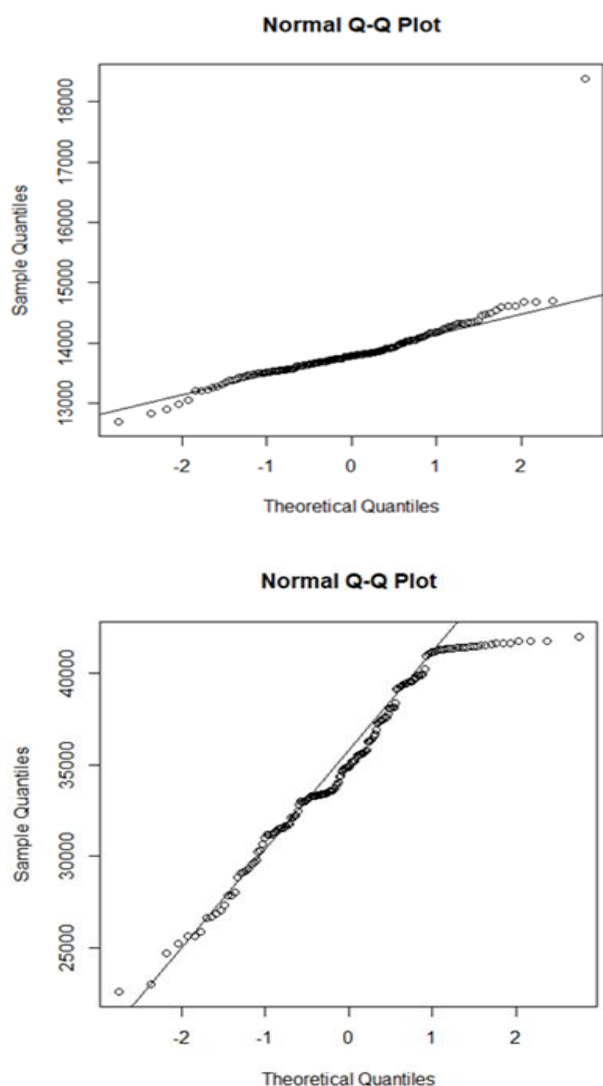
Figure 5. The figure shows the spread of the data
Total Area of spectrum
Photopeak 1 Net Area
Photopeak 2 Net Area

In figure 5, we notice that if the points are applied along a straight line, the data are homogeneous and follow to a normal distribution.

To study the homogeneity of the data, we use Eq(5) .

Table 4. Homogeneity of variances

Type of test		Tota.Net	Phot1Net	Phot2Net
bartlett.test		0.7281	0.187	0.8615
t-test	X.Sam.	0.4204	0.7854	0. 8441
	X.bar	0.9683	0.9718	0.9864
wilcox.test	X22	0.9586	0.224	0.2778
	Sample Par=1	0.9509	0.2099	0.2412
	Sample Par=0	0.6582	0.007248	0.5492

In bartlett. test we notice that the p. value is greater than 0.05, which means that the variance of the two groups is approximately equal at the level of significance 0.05, so we can say that there is homogeneity in all samples studied.

In the t- test, we find that the value is less than 0.05 which means the actual difference between the data is not equal to zero... so we choose the initial hypothesis according to Eq. 4, which mean that true difference in Mean is equal to zero. where: X0: Total, Y0: X1sample, X1: photo511MeV, Y1: X2 sample, X4: photo5111274MeV and Y4: X3 sample. for all the samples as figure 6.

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Figure 6. The figure shows the comparative of sampling mean
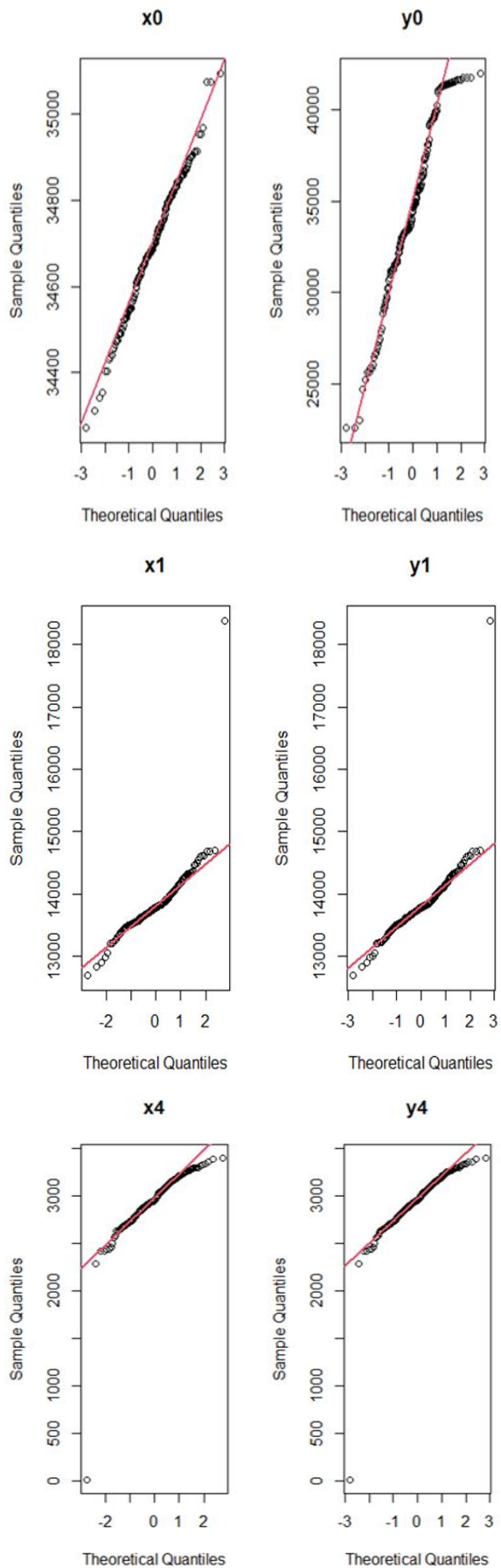
Pearson's Product-Moment Correlation

The tables 5 and 6 shows the Pearson correlation coefficient test and the linear Regression test for the studied variables.

Tables 5. Pearson correlation

data	p.value	Correlation	Type correlation	95% percent confidence interval
Total.Net and Pho511 Net	0.936	-0.005715334	negative	-0.1443419 0.1331312
Pho511 Net and Pho1247Nt	0.5323	0.04441521	positive	-0.09491067 0.18203449
Total.Net and Pho1247Nt	0.4472	0.05405186	positive	-0.08532906 0.19135784

We notice from Table 4. that the value of the correlation coefficient in the second and third groups was great than zero, which is a positive value, this means that there is a positive intermediate relationship between the variables, meaning that an increase in the net area of the photopeak of the sodium source is accompanied by an increase in the net area of the second photopeak. As for the first group, the correlation coefficient is negative and this means that there is a inverse relationship between the studied variables, We note the value of the correlation depends on the p. value, i.e. we consider as if there is no correlation between groups.

Table 6. Linear Regression test

data	p. value	Std. Error	Estimate	Min	Max	median	Residual	R-squared
Datta$sample ~Total.Net	$2.2e^{-16}$	$2.755e^{-17}$	1.000e+00	$-4.607e^{-14}$	$5.674e^{-13}$	$-2.990e^{-15}$	$4.098e^{-14}$	1
Datta$sample ~Pho511Net	0.936	$1.624e^{-03}$	$-1.306e^{-04}$	-107.00	967.73	-6.19	105.7	-0.005018
Datta$sample ~Pho1247Nt	0.4472	0.01553	0.01183	-130.88	956.91	-9.22	105.5	-0.002114
Pho511Net~Total.Net	0.936	3.1103	-0.2501	-12111.2	7310.3	-131.7	4626	-0.005018
Pho1247Nt~Total.Net	0.4472	$3.242e^{-01}$	$2.469e^{-01}$	-1108.2	4584.6	-38.9	482.2	-0.002114
Pho511Net~Pho1247Nt	0.5323	$6.802e^{-01}$	$4.255e^{-01}$	-12109.8	7252.2	-181.8	4622	-0.003068

Table 6. shows the simple linear regression of the studied samples, as the table contains the lowest error value, the highest value and the average error, as well as the value of the coefficient of determination and the residual value, which represents the total error value of the model, as the closer its value to zero, the better the quality of the model. The table also contains the p.value, which indicates the level of significance, as the results show that only the first group was less than the level of significance, while the rest of the groups were larger, and this means that the first group is significant or has importance than the rest of the groups.

Multiple Linear Regression

A method similar to simple line regression, but used for more than variable together, according to Table 6. It is noticed from the table that the value of the adjusted R^2 is closer to the R^2 multiple in the first group of the multimeter because the sample size is relatively large.

Table 7. Multiple linear regression

data	p.value	Std. Error	Estimate	Min	Max	median	R-squared	p.value
sample	0.851	8.574e-14	-1.608e-14	-4.577e-14	5.660e-13	-2.980e-15	1	< 2.2e-16
Total.Net	<2e-16	2.771e-17	1.000e+00					
Pho511Net	0.802	6.327e-19	1.590e-19					
Pho1247Nt	0.588	6.071e-18	3.296e-18					

It was also found that the p.value, based on the Fisher statistic, is less than 0.05, and this indicates the existence of a variable and independent of one reason that has an effect on the samples. Thus, Total.Net is the only significant group depending on the p. value.as figure 7.
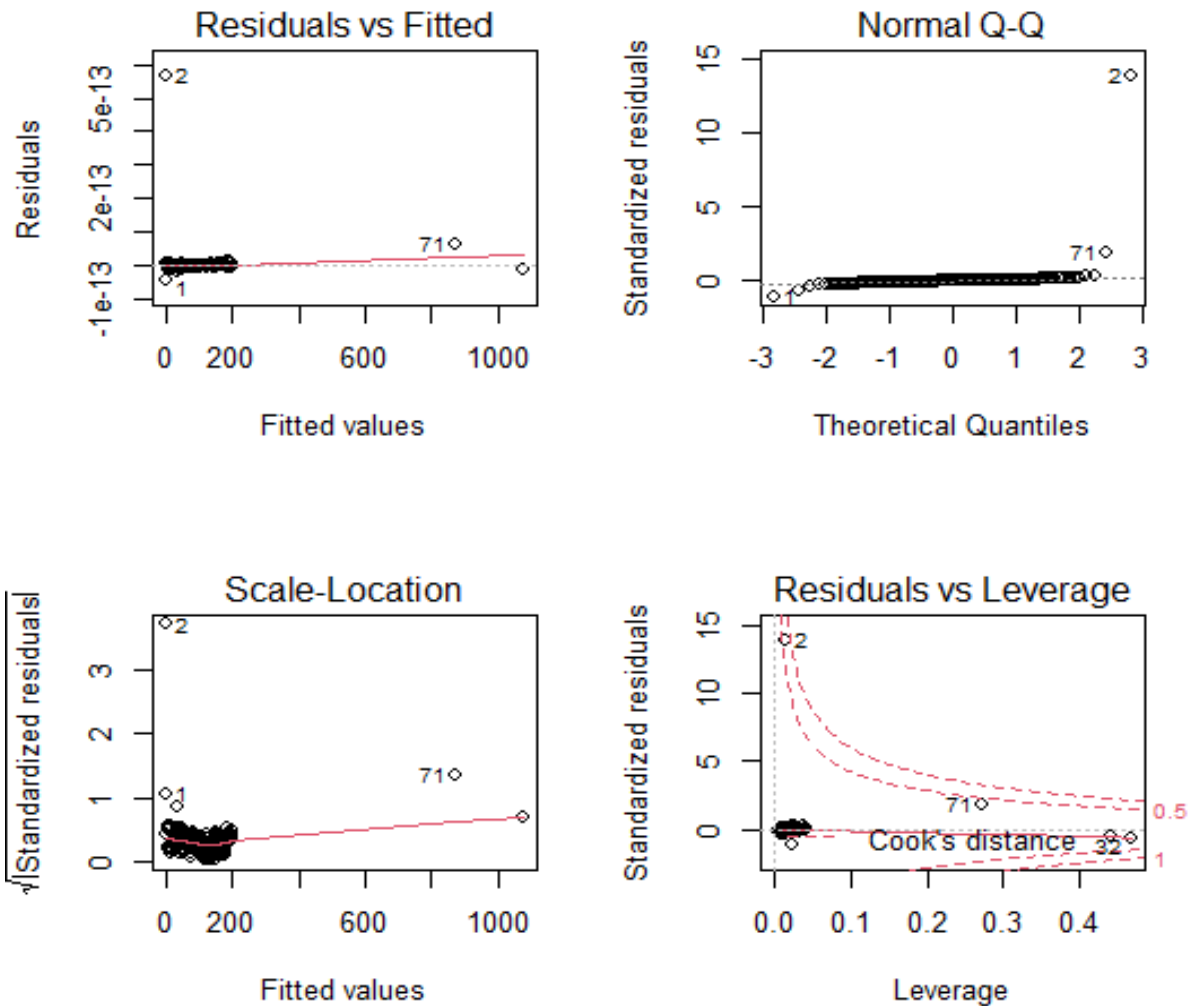
Figure 7. The figure shows Multiple linear regression

Figure 7 tests the conditions of linear regression. Regarding the first drawing (Residuals vs Fitted) it studies the validity of the existence of a linear relationship between sediments and the estimators. where we note that the relationship does not take a specific shape, which indicates the existence of a problem in the model to achieve this hypothesis.

The second drawing (Normal Q-Q) shows the normal distribution of sediments. When data are collected around the straight line, it indicates commitment of sediments to normal distribution.

The third drawing (Scale Location) shows the homogeneity of sediment variation, that is, it shows the mechanism of data spreading, where the beginning and end of the drawing must be similar in shape, and when one end is different from the other, this indicates the heterogeneity of sediment variation.

The fourth figure (Residuals vs Leverage) shows the presence of outliers, as the smaller the sample size will lead to an imbalance in some of the requirements of multiple linear regression.

Conclusions

1. In Kolmogorov-Smirnov test found that the studied data in sampling random are not obey to normal distribution.
2. In Shapiro test, it was found that the net total area of the spectrum data was not subject to the normal distribution while the standard sample data were subject to a normal distribution depending on the p. value.
3. In Q.Q. Normal Test, we notice the points in Total Area is not applied along a straight line, while the data in photopeak's are applied along a straight line so the data is homogeneous.
4. By using linear regression test, we found that there is no strong statistical relationship between the studied random variables.
5. By using T-test, we found that the studied samples (Total Net Area, Photopeak Net

Area) do not follow the normal distribution compared with the same random sampling standard that follow the normal distribution.

6. In Pearson correlation at the first and third groups was less than zero, which is a negative value, and this means that there is a weak inverse relationship between the studied variables. As for the second group, the correlation value was close to zero. positive, meaning that an increase in the net area of the first photopeak of the cobalt source is accompanied by an increase in the net area of the second photopeak.

7. The correlation depends on the p.value as the second group has a p.value approximately equal to the value of level of significance 0.05, but in the first and third groups, the p.value was greater than 0.05, and this means not relying on the value of the correlation, i.e. we consider as if there is no correlation between first and third groups.

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