Action Research in the Cultivation of Radish (Raphanus Sativus L.) using the Phytoremediation Technique

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Abstract

The research work was developed with students of the VI semester of the Biology and Chemistry program of the UNDAC, Chemistry Laboratory course, the objective was to apply action research, as a working method in the teaching-learning process for the recovery of the soils of the Yanamate Lagoon contaminated by mine tailings, through phytoremediation processes using radish cultures (Raphanus sativus L.). The research is applied and the design is quasi-experimental with two groups. The sample consisted of 21 plants in 40x50 plots, with 5cm between plants and 10cm between rows. The results show a weight/plant of 0.657 gr/plant for the experimental group compared to 0.834 gr/plant in the control group, plant size 25 cm in the control group and 38 cm for the experimental group. Metal absorption indicates an increase of 6.5% for the experimental group. Yield of 57.3% in the experimental group for number of radishes per plant. It is concluded that students improve by 85% the use, application of phytoremediation techniques and action research, teaching and learning increases by 92%, because they learn by doing.

Keywords: action research, phytoremediation, quasi-experimental design.

1. Introduction

Research in education is an essential tool to improve the teaching-learning process. By applying research in the educational process, both students and teachers acquire skills, create new knowledge and increase academic productivity (Scientific Bulletin). Inquiry-based learning is a teaching technique that aims to link teaching and research methods so that students can develop analysis, reflection, and reasoning skills, in addition to relating educational content to the production of knowledge (Parra, J., 2021; Ponce, L., 2015).

Therefore, teaching-learning research requires integrated strategies that develop professionally relevant cognitive skills and allow the interpretation, analysis, and categorization of messages, thus promoting the development of communicative and cognitive skills (Guadalupe, M., 2019).

Through classroom research, both students and teachers acquire skills, develop new knowledge, and increase academic productivity (Parra, J., 2021). Its implementation requires identifying the problem in the classroom that they need to improve, building a diagnosis of the current situation, gathering information and subsequently developing an action plan to address the problem through planned activities. Finally, to analyze the data collected and evaluate the impact of the actions carried out (Kemmis, S., 1988; Pérez, G., 1994).

Action research is a method that invites students to reflect on their practice, enrich their teaching methods and improve the way they learn (Rodríguez, L., 2016). Action research in the classroom requires a series of steps to be executed, such as planning, action, observation, and continuous reflection (Herreras, E., 2024).

Phytoremediation is a technology that uses plants to remove, reduce, transform, degrade, volatilize, or stabilize pollutants in soil, water, or air. It is considered a sustainable and economical alternative to the remediation of contaminated environments. It includes various techniques such as rhizosphere filtration, phytostabilization, phytodegradation, phytoextraction and phytovolatilization, whose application depends on the type of contamination, the conditions of the site and the required level of remediation (Delgadillo, L., 2011). Some of the most commonly used tools are systematic observation, interviews, field diaries, surveys, document analysis, and feedback.

The implementation of the action research method in the classroom on phytoremediation issues promotes meaningful learning and informed decision-making for both the teacher and the student.

To develop phytoremediation in the classroom, educational activities can be developed that aim to learn about the technique and its application in environmental remediation by the student. Some ideas that can be implemented in the classroom:

- Research on phytoremediation: students conduct research on phytoremediation topics, such as its principles, applications, benefits, and limitations; includes reviewing scientific studies on plants used in phytoremediation (Elliott, J., 1991).

- Classroom experiments: Students can conduct classroom experiments to demonstrate key concepts of phytoremediation using contaminated plants and soil in a controlled environment and then analyze the results (Thangavel, 2004).

- Field or laboratory visits: organize field visits, laboratory visits where real phytoremediation programs are being carried out, allowing students to use technology in real-life situations (Mendez, M., 2008). These activities are useful for empirical sciences such as biology, chemistry, environmental studies and for different educational and even higher educational levels.

To measure plant growth in phytoremediation crops, assessment tools can be used, such as:

- Growth stage observation sheet: observe and record different stages of plant growth, leaf development, flowering, fruit formation, etc. (Cherlinka, V., 2023).

- Measurement of plant growth rate: such as measurement of height, stem diameter, fresh and dry weight, etc.; providing quantitative data on plant growth in crops (Carberry, A., 2017).

Mining extraction, by its very nature, generates pollution of surrounding rivers and lakes, due to the discharge of liquid and solid waste, excessive sedimentation, contamination by chemical substances such as cyanide, sulfuric acid, arsenic, lead and mercury, etc. The contamination of water and soil generated by mining can have serious consequences for human health and aquatic organisms (Calcina, C., 2018; Echavarría, C., 2018).

The mining companies located in the surroundings of Cerro de Pasco, Peru, generate serious heavy metal pollution in rivers and lakes; since, when exposed to mineral extraction and purification processing plants, they cause water samples to present very high levels of heavy metals such as cadmium. This pollution has serious consequences for human health, causing severe blood toxicity, respiratory diseases, and other health problems.

As a result of mining activities, the water in rivers and lagoons is being polluted by waste from mineral processing, which is causing diseases in people's health (Murga, L., 2020). The situation is made worse by the fact that the government and mining companies are not taking steps to minimize pollution levels. In this context, the mining industry of Cerro de Pasco has one of the worst mining pollution conditions in the country, producing negative environmental and health impacts.

The Yanamate Lagoon is located on the western side of the Central Cordillera of Peru, 3.2 km southwest of the City of Cerro de Pasco, Tinyahuarco district, Pasco Province and Region, at an altitude of 4266 meters above sea level (Yanamate Lagoon. Wikimapia.org). The coordinates of its location are 10°42'39"S and 76°14'57"W. To date, it is totally affected by mining activities that have caused its total deterioration.

The radish (Raphanus sativus L.), is a herbaceous plant, whose roots are small tubers that are eaten in many countries. It has a spicy flavor and is consumed in salads. It has beneficial properties for the health of the person because it contains vitamin C, potassium, iodine, etc. It is classified by its shape and color, with varieties ranging from white to red or black. Table No. 1 shows the nutritional composition of the radish,

Table 01. Nutritional composition of radish

Compound	Quantity

Water	94 g
Carbohydrates	3.59 g
Fats	0.54 g
Proteins	0.6 g
Fiber	1.6 g
Ashes	0.54 g
Calories	20
Calcium	21 mg
Magnesium	9 mg
Potassium	232 mg
Phosphorus	18 mg
Iron	24 mg
Thiamine	0.29 mg
Riboflavin	0.005 mg
Niacin	0.045 mg
Ascorbic acid	0.3 mg

Data: Mendoza, J and Ochoa, D. (2015)

2. Materials and Methods

The research work is applied, quasi-experimental design with two groups:

Before After

Ex. 01 x 02

Cont 02

Where:

Ex. = Experiment

01 = Initial soil analysis of the Yanamate Lagoon

02 = Final analysis of the soil of the Yanamate Lagoon

X = Radish cultivation

The sample consisted of 21 plants in 40x50 plots, with 5cm between plants and 10cm between rows.

The hypotheses put forward for the research work were:

H0: The use of radish in the absorption of metals from soils from the Yanamate Lagoon by applying phytoremediation processes, indicates that after the process the concentration remains the same.

H0: The use of radish in the absorption of metals from soils from the Yanamate Lagoon by applying phytoremediation processes, indicates that after the process the concentration is different.

Soil samples were taken from the Yanamate Lagoon and a physical-chemical evaluation was made, which is shown in table No.3 Subsequently, these soils were treated to neutralize it up to a pH of approximately 7, using lime. It was conditioned, left to rest for 7 days, black soil was added (value of 50% initial weight of the sample) to improve the nutritional value of the soil and the corresponding evaluation was made. After that, he went on to sow it with radish seeds.

For the determination of pH (1:2 ratio), electrical conductivity, hardness and temperature, HANNA Instruments equipment was used. The analysis procedure used was the Electrometric Method.

The T80+ UV/VIS Spectrometer PG Instruments Ltd. was used for the identification and evaluation of the presence of nitrates and sulfates. Atomic absorption equipment was used to identify and evaluate the presence of metals. The technical standard was NTP 214.016:2000, Water for human consumption.

3. RESULTS

Assessment of student teamwork

The checklist was used as an instrument to evaluate the commitment to the activity developed and the attitude towards the partner. It was considered from 0 to 8 points: never, from 9 to 13 points: sometimes and from 14 to 20 always. The results are shown in Table No.2

Table 02. Checklist to evaluate teamwork

ITEM	CATEGORY	Never (%)	Sometimes (%)	Always (%)
1	Treats colleagues with respect	10	20	70
2	Ask questions related to the activity	5	17	78
3	Join the discussion	4	12	84
4	Clarifies facts, concepts, and terminology	12	23	65
5	Clearly expresses their views	14	17	69
6	Demonstrates initiative in the discussion of the case	8	15	77
7	Adapts to different group roles	0	8	92
8	Help your colleagues clear their doubts	9	16	75
9	Demonstrates initiative in the search for information	10	14	76
10	Participate in the field activity	0	0	100
11	They are satisfied with the final results	7	12	81

Fact: own elaboration

Interpretation: The results show that the activity carried out in the cultivation of radishes throughout the semester improves by more than 85% the interaction between students, respect,

discussion, bibliographic research and satisfaction with the results obtained. The greatest achievement has been the teaching-learning process that has improved its previous concepts and the total participation of students in classroom work by 92%

Evaluation of the land from the Yanamate Lagoon

Table 03. Preparation of the land from the Yanamate Lagoon

YANAMATE LAGOON						
Sample Weight	CaO Weight (g)	Water capacity (L)	Total weight (Kg)	pH	Add black soil	New pH
		7.5	12.5	3.2		
	15		12.515	4.9		
5 kg	15		12.530	5.6		
	15		12.545	6.4		
	15		12.560	7.5	15.060	7.68

Fact: own elaboration

Interpretation: the results show that the neutralization of the soil using lime is the most economical and within the reach of the students, it is also observed that the neutralization is stable over time; to support this, the soil was left to rest for 7 days. Black soil was used (in a ratio of 50% by weight of the initial sample), because in the Cerro de Pasco mountain range, it is the one most used by farmers.

Physicochemical evaluation of the soil from the Yanamate Lagoon

Table 04. Physicochemical evaluation of the soil from the Yanamate Lagoon

Parameter	Initial Soil Value	Final value after phytoremediation	L.M.P.
pH	1,24	8.31	6,5 – 8,5
STD	116,65	104.3	100
$NO3^-$	0,04	0,17	0,10
SO4=	992,5	987.3	400
Ace	44,6	44.21	0,5
CD	1,42	1.39	0,05
Cu	88,27	87.43	1,0
Faith	5624,03	5618,7	2,0
Mn	378,65	374.2	0,05
Pb	2,82	2.79	0,05
Zn	873,92	856.9	3,0

Fact: own elaboration

Interpretation: the results show that the physicochemical values evaluated both in the initial soil and in the phytoremediation activity, final data, are high compared to the Maximum Permissible Limits (L.M.P.) issued by the Ministry of the Environment. It can be said that on average the absorption of metals by phytoremediation process, the radish absorbed a value of 6.5%

Evaluation of radish crop yield

Table 05. Radish Plant Performance Evaluation

Parameter	Control Group	Experimental Group	Theoretical value
Growing Time (days)	65	80	35 – 50
Plant size	35 cm	58 cm	0.5 – 1.5 m
Weight (Kg/plant)-	0,734	0,547	0,954
Radish size	228 g	100 g	560 g
No. of radishes/plant	4	2	8
Yield (referred to No. of radishes harvested)	50	25	100

Fact: own elaboration

Interpretation: The results show that the cultivation of radish in the UNDAC Laboratory, in Cerro de Pasco, at room temperature of 12°C on average, at a pressure of 750 mmHg does not allow a real yield of the plants in both the control group and the experimental group, compared to the theoretical values. Likewise, it is noted that, in the experimental soil, despite neutralizing the soil, the growing conditions are still very aggressive and this is demonstrated both in the greater number of days it needs to grow, as well as in the product of radishes that is obtained per plant, a very small amount compared to the control group and the comparative average of the specialized literature.

Figure 1. Photos of radish cultivation by phytoremediation

Interpretation: the images show the cultivation of the radish, in the first image the planting of radish in the control group, in the second image the radish plants are shown for the experimental group, in the third image the harvested product, such as the radish.

Evaluation of the Working Hypothesis

Table 6. Compare the null and alternate hypothesis based on the data obtained

Paired Sample Testing									
		Paired differences							
					95% difference confidence interval				
		Stocking	Desv. Deviation	Desv. Average error	Inferior	Superior	t	Gl	Sig. (bilateral)
Par 1	Control Group Experimental Group	-3,49455	6,58776	1,98628	-,93117	7,92026	1,759	10	,109

Fact: own elaboration

Interpretation: the results show that the value of Sig. Obtained is greater than $\alpha = 0.05$ therefore the H0 is accepted: The use of radish in the absorption of metals from soils from the Yanamate Lagoon applying phytoremediation processes, indicates that after the process the concentration remains statistically the same. Therefore, the high level of contamination presented by the soil of Yanamate is not affected by absorption when radishes are grown; In other words, the radish is not a good phytoremediation plant.

4. Discussion

The evaluation of the teamwork of the students that exceeds 85% of the commitment of the members allows us to point out that it is a good option, because it awakens in the student motivation, critical judgment, among other things (García, M., 2023). In this regard, the journal Active Learning in Higher Education indicates that teamwork can improve peer assessment and self-assessment to measure the effectiveness of teamwork (Andreu, A., 2014).

The journal CREHANA, for teamwork, suggests an alternative approach, which should consider criteria such as communication, collaboration, diversity, and participation, using surveys, questions, and exercises as evaluation tools (García, M., 2023).

Regarding the contamination of the Yanamate Lagoon, according to the physical-chemical analysis data obtained, it is shown that it is totally contaminated, with no presence of life and flora observed in the place.

According to an article by Mongabay, it indicates that 90% of gold-related mining affects 173 major rivers, 80% of which have doubled their sediment load, leading to pollution in the environment, changes in biodiversity, and changes in river flow (Rivers at Risk, 2023)

The pollution of rivers and lagoons caused by mining is in many cases due to the release of chemical substances such as cyanide and sulfuric acid, which affect both the environment and the balance of public health (EV Charging Energy, 2023).

Phytoremediation processes allow the recovery of contaminated soil and water (Bernal, A., 2014), which is based on natural processes of plants and their root-associated microbiota that degrade and/or bind pollutants. Phytoremediation help restore soil health and restore its ability to perform important functions such as biomass production, organic matter decomposition, nutrient recycling, water purification, air quality regulation, pollutant removal, and more

(Goicochea, P., 2022). In the research work regarding the improvement of soil recovery has been very small.

5. Conclusions

The Action Research method, used in our research, strongly improves the bond between students and the teacher, generating respect between them, group work and predisposition for bibliographic and field research.

The cultivation of radishes by applying phytoremediation processes allows the student to learn about new techniques for the recovery of soils contaminated by industry and their application through experimental field or laboratory work and their respective results.

The students also point out the importance of using statisticians, applying statistical software such as SPSS v.26 that is easy to handle and interpret; as is the case of our research to validate our hypotheses by comparing means for paired samples through the data obtained in the research.

Finally, it can be concluded that, by evaluating students in the work of experimental development, they demonstrate a greater scientific assessment and critical judgment, having a greater ability to understand the problems that arise and their approach to point out a possible solution.

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