

# Safety risk assessment in a drinking water treatment plant using the NTP 330 method

María Belén Vinces-Obando<sup>a</sup>, Luis David Balarezo-Saltos<sup>b\*</sup>, Carlos Alfredo Salas-Macías<sup>a</sup>, Fernando Ramón Isea-León<sup>b</sup>, Rodolfo Patricio Panta-Vélez<sup>b</sup> & Dayana Elizabeth Briones-Bermúdez<sup>c</sup>

<sup>a</sup> Departamento de Ciencias Agronómicas, Facultad de Ingeniería Agroambientales, Universidad Técnica de Manabí, Santa Ana, Ecuador. maria.vinces@utm.edu.ec, carlos.salas@utm.edu.ec

<sup>b</sup> Departamento de Acuicultura, Pesca y Recursos Naturales Renovables, Facultad de Acuicultura y Ciencias del Mar, Universidad Técnica de Manabí, Bahía de Caráquez, Ecuador. luis.balarezo@utm.edu.ec, fernando.isea@utm.edu.ec, rodolfo.panta@utm.edu.ec

<sup>c</sup> Departamento de Laboratorio Clínico, Facultad de Ciencias de la Salud, Universidad Estatal del Sur de Manabí, Jipijapa, Ecuador. briones-dayana0165@unesum.edu.ec

Received: June 25<sup>th</sup>, 2025. Received in revised form: November 14<sup>th</sup>, 2025. Accepted: November 21<sup>st</sup>, 2025.

## Abstract

In Ecuador, the lack of attention to occupational safety in small and medium-sized enterprises, which constitute 98% of the total, has increased workplace accidents. To assess this situation, a Checklist based on the Guide of the National Institute for Occupational Safety and Health (INSHT) of the Ministry of Labor was applied. The methodology was then adapted to evaluate specific working conditions in SMEs and the NTP 330 method was used, which considers criteria such as efficiency, exposure, probability, and consequences to determine the risk level. Fifty-eight hazards were identified, including falls of people from different levels, falling objects due to collapse, and blows or cuts caused by tools, each with an incidence of 10%. The distribution area presented the highest number of risks (15), and the high-risk level predominated. The application of the method allowed for a comprehensive assessment, highlighting the urgent need for preventive measures.

**Keywords:** safety risks; risk assessment; drinking water treatment plant.

# Evaluación de riesgos de seguridad en una planta de tratamiento de agua potable mediante el método NTP 330

## Resumen

En Ecuador, la falta de atención a la seguridad laboral en las pequeñas y medianas empresas, que constituyen el 98 % del total, ha incrementado los accidentes laborales. Para evaluar esta situación, se aplicó una Lista de Verificación basada en la Guía del Instituto Nacional de Seguridad y Salud en el Trabajo (INSHT) del Ministerio de Trabajo. Luego, se adaptó la metodología para evaluar condiciones laborales específicas de PYMES y se utilizó el método NTP 330, que considera criterios como eficiencia, exposición, probabilidad y consecuencias para determinar el nivel de riesgo. Se identificaron 58 peligros, destacando la caída de personas a diferentes niveles, caída de objetos por derrumbe y golpes o cortes con herramientas, cada uno con una incidencia del 10 %. El área de distribución presentó el mayor número de riesgos (15) y predominó el nivel de riesgo alto. La aplicación del método permitió una evaluación integral, destacando la necesidad urgente de medidas preventivas.

**Palabras clave:** riesgos de seguridad; evaluación de riesgos; planta de tratamiento de agua potable.

## 1 Introduction

Since the 20th century, occupational safety has gained importance globally, driving the development of techniques and methods aimed at preventing occupational

risks. However, many of these methodologies are not applied adequately, since risk level assessments are often inaccurate [1]. This situation has led to approximately 330 million occupational accidents being recorded worldwide towards the end of that century, of which 2.4 million

resulted in fatalities [2,3]. Until 2016, the highest deaths or disability-adjusted life years per capita were recorded in Oceania, Southeast Asia and central sub-Saharan Africa [4].

Additionally, non-fatal occupational accidents are estimated to generate an economic burden equivalent to 4% of global GDP annually, reflecting their significant impact on the global economy. These figures are especially alarming in low- and middle-income countries, where informal sectors and high-risk industries, such as agriculture and mining, predominate, exacerbating occupational injuries and deaths due to limited implementation of preventive and occupational safety measures [5].

In Latin America and the Caribbean, efforts to establish effective preventive processes have increased. However, many institutions prioritize other aspects over occupational safety, which makes adequate risk management difficult [6]. Unlike developed countries, where preventive guarantees are a priority, greater vulnerability in work environments persists in the region [7].

In Ecuador, the lack of interest in occupational safety issues is evident, even though 98% of organizations are small businesses, where it would be feasible to implement specific risk controls. This lack of action has contributed to the increase in workplace accidents [8,9]. In addition, the absence of solid preventive policies and their lack of implementation have generated a constant exposure of workers to occupational risks, further weakening occupational safety in the country [10,11]. Likewise, occupational safety faces serious challenges, especially in strategic sectors where the risks associated with productive activities are high. Even though 98% of organizations are small businesses, there is a notable lack of interest in the implementation of preventive measures, which could facilitate a more specific control of occupational risks. This situation has led to an increase in unsafe working conditions and a gradual weakening of safety policies [8].

In this context, water treatment plants present a particularly challenging work environment, given that their operations involve complex processes and constant handling of specialized equipment and chemicals. These activities generate significant occupational risks that require rigorous management and adequate preventive measures [9]. However, limited application of safety policies and lack of access to training programs aggravate workers' exposure to accidents.

## 2 Materials and methods

### 2.1 Characterization of the plant under study

The water treatment plant under study (located at geographic coordinates x: 563,064.22 m, y: 988,1079.89 m), built at the beginning of the 21st century, was designed to meet the growing demand of a rapidly growing population, ensuring access to clean and safe water. With a production capacity of approximately 90,000 m<sup>3</sup> per day, the plant operates continuously through a water treatment process that includes stages such as pretreatment, coagulation and

flocculation, sedimentation, filtration, disinfection, and storage before distribution. This infrastructure, equipped with high-quality electromechanical components and supervised by a team of specialized operators and technicians, faces challenges such as variability in raw water quality due to extreme weather events, increased demand, and the impacts of climate change.

In response, treatment processes have been optimized and investments have been made in monitoring technologies to ensure its efficient operation. However, these operations entail significant occupational hazards associated with equipment handling, exposure to chemicals, and working in conditions that require constant attention. Assessing and managing these risks is critical to protecting the physical and mental integrity of the 33 workers involved in the various stages of the process. Therefore, implementing effective preventive measures not only contributes to employee safety but also to meeting quality and sustainability objectives in the supply of drinking water.

### 2.2 Risk identification

To identify occupational risks in the workplace, an observational study was previously carried out using a “Check-list”, in which the risk factors were highlighted based on the considerations of the instrument of the “Guide of the National Institute for Safety and Hygiene at Work in Construction” [12].

Subsequently, the practical methodology for identifying working conditions in small and medium-sized companies of the INSHT [13] was used and adapted. Considering the accident risks (safety) detailed in table 1.

Table 1.  
Most common forms of occupational risks (safety).

Cod.	Risk of accident
10	Person falls from a different level.
20	Fall of people at the same level.
30	Falling objects due to collapse or landslides.
40	Falling objects during handling.
50	Falling detached objects.
60	Stepping on objects.
70	Collisions with stationary objects.
80	Collisions with moving objects.
90	Bumps/cuts from objects or tools.
100	Projection of fragments or particles.
110	Entrapment by or between objects.
120	Entrapment due to overturning machines or vehicles.
130	Overexertion.
140	Exposure to extreme ambient temperatures.
150	Thermal contacts.
161	Direct electrical contacts.
162	Indirect electrical contacts.
170	Exposure to harmful or toxic substances.
180	Contact with caustic and/or corrosive substances.
190	Exposure to radiation.
200	Explosions.
211	Fires. Starting factors.
212	Fires. Spread.
213	Fires. Fighting methods.
214	Fires. Evacuation.
220	Accidents caused by living beings.
230	Vehicle collisions or hits.

Source: INSHT, 2000.

### 2.3 Risk assessment

The risk assessment was carried out based on the NTP 330 method [14,15], a methodology that differs from the others, because the weighting of the levels is not subject to the evaluator's subjectivity, for this purpose, the security risks are evaluated through the interaction of specific criteria or levels [16]. The method consists of determining the deficiency based on the level of exposure, which subsequently yields the corresponding probability, as illustrated in Fig. 1. From this probability, the consequence level can be established, and ultimately, the overall risk level is determined, as detailed below:

- 1) Deficiency level:
  - Very poor: Significant risk factors have been detected that make it highly possible for failures to occur. The set of preventive measures in place regarding risk is ineffective.
  - Deficient: A significant risk factor has been identified that needs to be corrected. The effectiveness of the set of preventive measures is significantly reduced.
  - Improvable: Minor risk factors have been detected. The effectiveness of the set of existing preventive measures with respect to risk is not significantly reduced.
- 2) Exposure level:
  - Continuous: If the worker is working for a long time.
  - Frequent: If the worker is there several times during his/her workday, although for short periods of time.
  - Occasional: If the worker is ever on duty during his/her workday and has a short period of time.
  - Sporadic: Irregularly.
- 3) Probability level:
 

Where:

  - Very High: Poor situation with continued exposure or very poor situation with frequent exposure. Risk materialization usually occurs frequently.
  - High: Poor situation with frequent or occasional exposure or very poor situation with occasional or sporadic exposure. The risk may materialize several times in the working life cycle.
  - Average: Poor situation with sporadic exposure or improvable with continuous or frequent exposure. The risk may materialize once a year.
  - Low: Situation could be improved with occasional or sporadic exposure. The risk is not expected to materialize, although it may be conceivable.
- 4) Level of consequence:
 

Based on the result of the probability level, the focus is on determining the level of consequence of the risk using Fig. 2.

NTP method 330		Exposure Level			
		Continue	Frequent	Occasional	Sporadic
Level of Deficiency	Very poor	Very high	Very high	High	High
	Deficient	Very high	High	High	Average
	Improvable	Average	Average	Low	Low

Figure 1. Probability level.  
Source: INSHT, 2000.

NTP method 330		Probability			
		Very high	High	Average	Low
Consequence	Mortal	Serious and imminent	Serious and imminent	High	High
	Very serious	Serious and imminent	High	Half	Half
	Serious	High	Half	Half	Low
	Mild	Half	Half	Low	Tolerable.

Figure 2. Level of consequence.  
Source: INSHT, 2000.

Where:

- Mortal: One or more dead.
- Very serious: Serious injuries that may be irreparable.
- Serious: Injuries with temporary work incapacity.
- Mild: Minor injuries that do not require hospitalization.

#### 5) Determine the level of risk:

Based on the result obtained in figure 2, the action to be taken based on the level of risk of the worker's activity is considered:

- Serious and imminent: Stop the activity. Correct and check the effectiveness of the correction.
- High: Urgent correction and adoption of control measures.
- Half: Correction and adoption of control measures.
- Low: Improve if possible.
- Tolerable: Satisfactory situation.

### 2.4 Jobs descriptions

Table 2 outlines the working conditions associated with each job position across the organization, assessing the risk levels of five operational areas as detailed below:

Table 2.  
Description of the areas of work under study.

Area	Description
Operator of the collection and mechanical roughing area	As this is the first process where raw water is captured, the operator has the task of frequently cleaning the bulky materials that are carried by the channel flow and that are trapped in the mechanical roughing. Subsequently, all the waste is transported by a conveyor belt to a container.
Rapid mix process operator	Before the chemicals are integrated into the treatment processes, operators are tasked with transporting the substances from a chemical storage warehouse using a forklift to a first mixing point, where they are conveyed via pipelines to the xiphoid tank and the agitator.
Operator of the decanted water filtration stage	The operator has the power to manually clean the decanters and filters every 15 days. These are also operated by control stations.
Distribution area operator	In this position, workers are in charge of controlling the operations and functionality of the pumps for the corresponding distribution of drinking water.
Laboratory area operator	The laboratory manager and his assistant are responsible for frequently measuring the corresponding parameters for controlling water quality processes.

Source: The authors.

### 3 Results

#### 3.1 Risk identification

Based on the execution of the “Check List” and the practical methodology for identifying working conditions in small and medium-sized companies of the INSHT, table 3 details the total number of risks and safety risk factors that were determined in the work positions evaluated at the drinking water treatment plant.

Table 3.  
Risk identification results.

Cod	Risks	Risk factors
10	Person falls from a different level	Lack of protective railings in water catchment areas.
		Use of stairs in poor condition.
		Railings surrounding the xiphoid tank in poor condition.
		Unstable railings around the decanters.
		Use of unstable railings.
20	Fall of people at the same level	Lack of Personal Protective Equipment for cleaning decanters.
		Wet floor.
		Slippery floor.
30	Falling objects due to collapse or landslides	Mechanical roughing in deterioration.
		Forklift with lack of maintenance
		Unstable stacked sacks.
		Lack of selective shelving
		Use of improvised structures for cleaning decanters.
40	Falling objects during handling	Use of a ladder with imperfections.
		Incorrect handling of the forklift.
50	Falling detached objects	Use of inappropriate tools for cleaning decanters.
		Lack of maintenance to railings and stairs.
60	Stepping on objects	Presence of objects in the mechanical grinding circulation routes.
		Presence of unnecessary materials on the decanter circulation paths.
		Presence of objects on the circulation routes of the distribution area.
		Lack of signage in the roughing area.
70	Collisions with stationary objects	Signs in poor condition during the rapid mixing process.
		Lack of signage in the distribution area.
		Slippery floor.
		Small workplace space.
80	Collisions with moving objects	Loss of control of the forklift.
90	Bumps/cuts from objects or tools	Lack of protective elements in mechanical grinding.
		Handling of rakes for bulky materials trapped in the grates.
		Handling obsolete tools.
		Lack of maintenance at the decanter control stations.
		Use of inappropriate materials.
100	Projection of fragments or particles	Poor labeling of some materials and substances.
		Conveyor belt without protective elements.
		Elements of obsolete checkpoints.
110		Lack of protection in the pump area.
		Handling of the conveyor belt.
		Lack of signage during the rapid mixing process.

	Entrapment by or between objects	Improvisation of tools for operator mobility on decanters.
120	Entrapment due to overturning machines or vehicles	Forklift trapped between bags.
130	Overexertion	Manual handling of some bags.
161	Direct electrical contacts	Electrical connection in the distribution area with lack of maintenance.
		Inadequate electrical system for mechanical roughing.
162	Indirect electrical contacts	Electrical system with lack of maintenance at the control stations.
		Electrocution due to the presence of water near the electrical connections of the pumps.
		Handling of electrical equipment.
170	Exposure to harmful or toxic substances	Lack of special masks.
		Frequent use of chemical reagents.
180	Contact with caustic and/or corrosive substances	Use of chemical substances for the analysis of water parameters.
200	Explosions	Alteration of pump operation. Use of flammable substances.
211	Fires. Starting factors	Contact of the electrical system with drinking water.
		Incorrect handling of electrical equipment. Incorrect handling of flammable substances.
212	Fires. Spread	Presence of drinking water near electrical systems.
214	Fires. Evacuation	Signs in poor condition.
220	Accidents caused by living beings	Bite or sting from an animal that is carried by the current into the catchment area.
230	Vehicle collisions or hits	Lack of pedestrian traffic routes in the area where the forklift operates.

Source: The authors.

Given the results obtained from the identification of risks in the water treatment plant, Fig. 3 shows the risks that had the greatest impact on the tasks performed by the workers. Where: falls of a person from different levels; falling objects due to collapse or landslides and blows/cuts from objects or tools, obtained a 10% higher frequency than the other risks.

#### 3.2 Risk assessment

The assessment of safety risks at the drinking water treatment plant showed that the highest incidence of risks occurred in the distribution area, categorizing the risk levels into “serious and imminent”, “high” and “medium”, showing a total of 15 risk levels, as shown in Fig. 4.

Fig. 5 shows the general results of the safety risk assessment at the drinking water treatment plant, showing that the most representative level was “high” with 48.28% incidence, leading to the need for “urgent corrections and adoption of control measures”. It is important to note that tolerable levels were not obtained in this investigation.

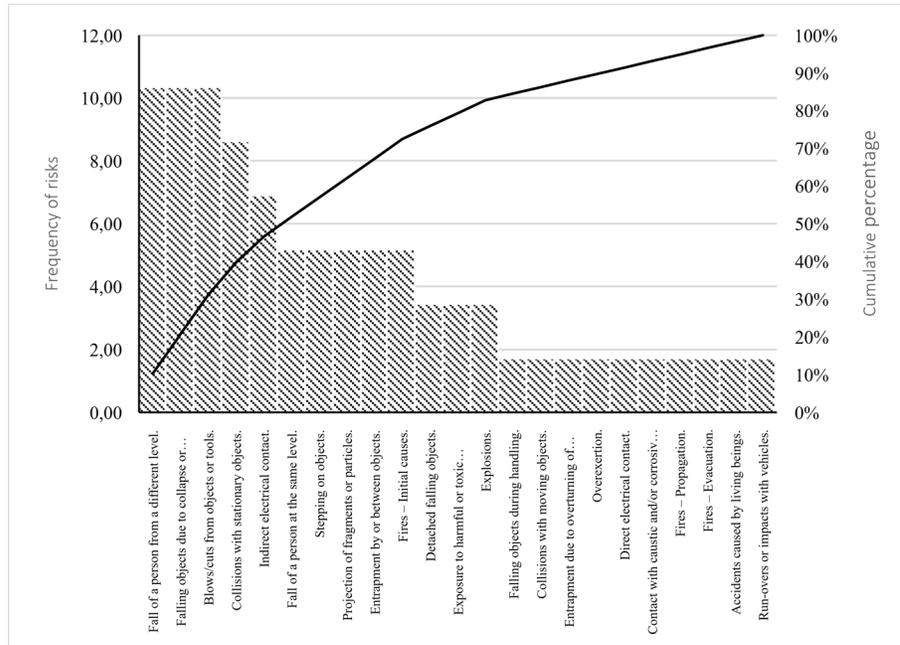


Figure 3. Results of the identification of safety risks at the drinking water treatment plant.  
Source: The authors.

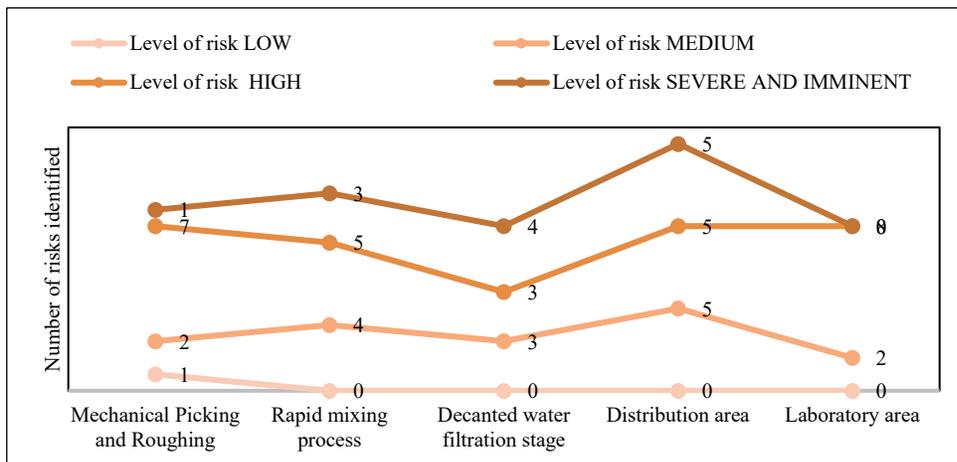


Figure 4. Results of the security risk levels in the evaluated jobs.  
Source: The authors.

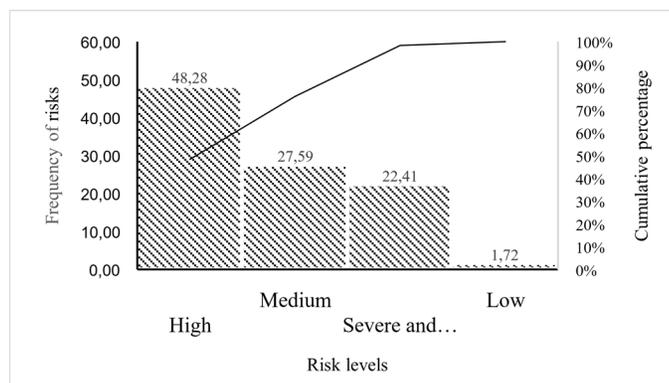


Figure 5. Overall result of safety risk levels at the water treatment plant.  
Source: The authors.

#### 4 Discussion

The results of this study identified the most common risks as “person falling from a different level”, “objects falling from a collapse or landslide” and “blows/cuts from objects or tools”. These risks are common in companies of this nature due to the structural and operational form of their processes [17]. In particular, the risk of falling from a different level is intrinsically related to other types of risks, due to the chain of events that this type of accident can trigger [18]. Previous studies have determined that falls from a height represent up to 50% of occupational risks in various companies [19], which corroborates the relevance of these findings in the context of the evaluated water treatment plant.

The distribution area stood out as the zone with the highest incidence of risks. This situation is associated with the dependence on pumps, whose maintenance and operation involve multiple risk factors that affect not only the physical safety of workers, but also their overall health, influencing occupational diseases, fatigue and job dissatisfaction [20]. This combination of physical and psychosocial risks emphasizes the importance of comprehensive safety management in industrial environments.

In terms of assessment, the “high” risk level was the most representative, covering 48.28% of the assessed working conditions. This classification highlights the need to implement “urgent corrections and adoption of control measures”, measures aimed at the elimination, reduction or mitigation of the identified risks [14,15,21]. The application of these corrective actions not only positively impacts the quality of working life of workers, but also strengthens the institutional image and competitiveness of companies through effective preventive management models [22].

In general terms, the application of the NTP 330 method revealed that the high incidence of risks associated with falls from different levels and falling objects is closely linked to the operational characteristics of the evaluated plant [23]. Maintenance activities involving pumps, valves, and pipelines require continuous movement across platforms and metal structures which, due to frequent moisture exposure, substantially increase the likelihood of severe accidents [24]. The identification of 58 hazards reflects not only the inherent complexity of the production process but also the inadequacy of the preventive controls currently in place.

These findings are consistent with previous studies conducted in similar facilities, thereby reinforcing the validity of the analysis and underscoring the urgency of implementing comprehensive corrective measures [17,23,24]. Such measures should integrate engineering interventions, improvements in operational infrastructure, and systematic training and preventive management programs designed to reduce both the probability and severity of the identified incidents [25].

#### 5 Conclusions

The findings of this study indicate that the predominant occupational risks identified in the evaluated drinking water treatment plant originate mainly from deficiencies in infrastructure maintenance, inadequate safety signaling, and

the use of obsolete equipment. The distribution area emerged as the most critical zone due to the operational demands of the pump systems, which expose workers to physical hazards and contribute to broader impacts on their well-being, including fatigue, stress, and susceptibility to occupational illnesses. The identification of multiple high-risk conditions evidences the limited effectiveness of the preventive measures currently implemented.

The high proportion of risks classified as “high level” underscores the urgent need to implement corrective actions and more robust control mechanisms aimed at eliminating or mitigating hazardous conditions. Intervention strategies should prioritize engineering controls, modernization of equipment, improvement of signage and accessibility, and the strengthening of maintenance and operational protocols. These actions are essential not only to reduce the probability and severity of incidents but also to establish a safer and more efficient operational environment.

The application of the NTP 330 method proved instrumental in identifying critical areas and establishing intervention priorities, providing a structured and systematic assessment of exposure levels, control efficiency, probability of occurrence, and severity. In addition, this comprehensive approach reinforces the importance of adopting an integrated risk-management framework that incorporates engineering solutions, organizational policies, and continuous training. Strengthening occupational safety not only protects workers’ physical and mental integrity but also contributes to the long-term sustainability of plant operations and supports progress toward the Sustainable Development Goals by ensuring a reliable and safe supply of potable water.

#### References

- [1] Céspedes, G., and Martínez, M., An analysis of occupational health and safety in the Cuban business system. *Latin American Journal of Social Law*; [online]. (22), 2016. Available at: [https://www.scielo.org.mx/scielo.php?script=sci\\_arttext&pid=S1870-46702016000100001](https://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S1870-46702016000100001)
- [2] Toro, J., Vega, V., and Romero, A., Occupational accidents and occupational diseases and their application in ordinary justice. *Journal of University and Society*, [online]. 13(2), pp. 357-362. 2021. Available at: <http://scielo.sld.cu/pdf/rus/v13n2/2218-3620-rus-13-02-357.pdf>
- [3] Takala, J., Global estimates of traditional occupational risks. *Scandinavian Journal of Work, Environment and Health, Supplement*; [online]. (1), pp. 62–67. 2005. Available at [https://www.sjweh.fi/show\\_abstract.php?abstract\\_id=940](https://www.sjweh.fi/show_abstract.php?abstract_id=940)
- [4] Driscoll, T., Rushton, L., Hutchings, S.J., Straif, K., Steenland, K., Abate, D., Abbafati, C., Acharya, D., Adebayo, O.M., Afshari, M., Akinyemiju, T., Alahdab, F., Anjomshoa, M., Antonio, C.A.T., Aremu, O., Ataro, Z., Ayala-Quintanilla, B.P., Mattar-Banoub, J.A., Barker-Collo, S.L., y Lim, S., Global and regional burden of disease and injury in 2016 arising from occupational exposures: a systematic analysis for the Global Burden of Disease Study 2016. In *Occupational and Environmental Medicine*, 77(3), pp. 133-141, 2019. DOI: <https://doi.org/10.1136/oemed-2019-106008>
- [5] Abdalla, S., Apramian, S.S., Cantley, L.F., y Cullen, M.R., Occupation and Risk for Injuries. In *Disease Control Priorities, 3<sup>rd</sup> Edition, Injury Prevention and Environmental Health*. 1(1), Art. 120694, 2017. DOI: [https://doi.org/10.1596/978-1-4648-0522-6\\_ch6](https://doi.org/10.1596/978-1-4648-0522-6_ch6)
- [6] Silva, M., Merino, P., Benavidez, F., López, M., and Gómez, A., Occupational health in Ecuador: a comparison with surveys on working conditions in Latin America. *Brazilian Journal of Occupational Health*. [online]. 45(20), 2020. Available at: <https://www.scielo.br/j/rbso/a/THMYXrBb9cwQQ4rbkbcWbvP/?lang=es>

- [7] Giuffrida, A., Iunes, R.F., and Savedoff, W.D., Occupational risks in Latin America and the Caribbean: Economic and health dimensions. In *Health Policy and Planning*. 17(3), pp. 235-246, 2002. DOI: <https://doi.org/10.1093/heapol/17.3.235>
- [8] Alcivar, D., Espinoza, A., Artega, M., and Escobar, K., ENEMDU Ecuador: study of the perception of safety and health. *Revista Salud UIS*. 2020; [online]. 52(3), pp. 215-223. 2018. Available at: <http://www.scielo.org.co/pdf/suis/v52n3/2145-8464-suis-52-03-215.pdf>
- [9] López-López, J.C., and Alcivar-Espín, R.A., Industrial safety and occupational health strategies: the case of a water treatment plant in Ecuador. *Journal of Business and Entrepreneurial Studies*. 7(3), Art. 341, 2023. DOI: <https://doi.org/10.37956/jbes.v7i3.341>
- [10] Flores, C., Capa, C., and Capa, L., Occupational health and safety management to reduce workplace accidents in companies in Machala-Ecuador. *Journal of University and Society*, [online]. 10(2), pp. 304-309. 2018. Available at: <http://scielo.sld.cu/pdf/rus/v10n2/2218-3620-rus-10-02-310.pdf>
- [11] Acosta-Pérez, P.B., Espinosa-Pinos, C.A., Acuña-Mayorga, J.M., and Lascano-Arias, G., Occupational Risks: a comparative study of the most common indicators in Uruguay, Cuba and Ecuador. ECTM, IEEE 7<sup>a</sup> Ecuador Technical Chapters Meeting. pp. 1-4, 2023. DOI: <https://doi.org/10.1109/ETCM58927.2023.10309063>
- [12] Ministry of labor. basic guide to the prevention of occupational risks in construction. [online]. 2022. [cited January 9<sup>a</sup>, 2023]. Available at: <https://www.trabajo.gob.ec/wp-content/uploads/2024/01/Guia-basica-de-prevencion-de-riesgos-laborales-en-la-construccion.pdf>
- [13] National Institute for Safety and Hygiene at Work (INSHT). Evaluation of working conditions in small and large companies. [online]. 2000. [cited on January 9<sup>a</sup>, 2023]. Available at: [https://www.insst.es/documents/94886/211340/Condiciones\\_trabajo\\_PYMES.pdf/0452965e-d0bb-408d-9806-fac257562168?t=1587581004696](https://www.insst.es/documents/94886/211340/Condiciones_trabajo_PYMES.pdf/0452965e-d0bb-408d-9806-fac257562168?t=1587581004696)
- [14] National Institute for Safety and Hygiene at Work (INSHT). NTP 330: Simplified system for the assessment of accident risks. [online]. 1993. [cited on January 9<sup>a</sup>, 2023]. Available at: [https://www.insst.es/documents/94886/326827/ntp\\_330.pdf/e0ba3d17-b43d-4521-905d-863fc7cb800b](https://www.insst.es/documents/94886/326827/ntp_330.pdf/e0ba3d17-b43d-4521-905d-863fc7cb800b)
- [15] Vitrián, F.J., Núñez, J.M., Román, F., Arévalo, T., Occupational risk prevention techniques: safety at work and industrial hygiene. UNIR, editor: 978-84-15626-11-4 (Volume II); 2018.
- [16] Moyano, J., Jácome, M., García, A., Orozco, J., and Fuertes, V., Evaluation of mechanical risks in engineering workshops and laboratories applying the NTP 330 standard. *Perfiles Magazine*, [online]. 17(1), pp. 41-62 2017. Available at: <http://ceaa.esPOCH.edu.ec:8080/revista.perfiles/Articulos/Perfiles17Ar t6.pdf>
- [17] Del-Pezo, O., Occupational health and safety management model for the drinking water company, "Aguas de la península-AGUAPEN SA". [Thesis prior to obtaining the master's degree in quality, environment and safety management systems]. Guayaquil: Universidad Politécnica Salesiana. 2013.
- [18] Wong, L., Wang, Y., Law, T., y Lo, C.T., Association of root causes in fatal fall-from-height construction accidents in Hong Kong. *Journal of Construction Engineering and Management*, 142(7), pp. 1-12. 2016. Available at: [http://dx.doi.org/10.1061/\(ASCE\)CO.1943-7862.0001098](http://dx.doi.org/10.1061/(ASCE)CO.1943-7862.0001098)
- [19] Zlatar, T., Lago, E.M.G., Soares, W.A., Baptista, J.S., y Barkokébas Junior, B., Falls from height: analysis of 114 cases. 29, Art. 91, 2019. DOI: <https://doi.org/10.1590/0103-6513.20180091>.
- [20] Lovely, L., y Sekar, F., Preventing musculoskeletal disorders due to manual material handling in the production process of clean water. *Journal Industrial Servicess*, 10(1), pp. 125-132. 2024. DOI: <http://dx.doi.org/10.62870/jiiss.v10i1.24471>
- [21] International Labour Organization (ILO). Occupational safety and health inspection, training module for inspectors. [online]. 2017. [cited 10<sup>a</sup> September 2024]. Available at: [https://www.ilo.org/sites/default/files/wcmsp5/groups/public/@americas/@ro-lima/@ilo-buenos\\_aires/documents/publication/wcms\\_592318.pdf](https://www.ilo.org/sites/default/files/wcmsp5/groups/public/@americas/@ro-lima/@ilo-buenos_aires/documents/publication/wcms_592318.pdf)
- [22] Yturalde, J., and Franco, O., Workplace accidents in public and private companies in Ecuador in the period 2014-2015. *Dominio de las Ciencias*, 6(2), pp. 1022-1043. 2020. DOI: <http://dx.doi.org/10.23857/dc.v6i2.1263>.
- [23] Krasnova, A., and Radygina, E., Occupational safety when working at height. *Sbornik Naučnyh Trudov Angarskogo Gosudarstvennogo Tehničeskogo Universiteta*, 2024(1), pp. 363-366. 2024. DOI: <https://doi.org/10.36629/2686-7788-2024-1-363-366>.
- [24] Delshah, M., Rahimpour, H.R., and Rahimpour, M.R., Chemicals transporting systems safety: pumps, pipelines, and valves. *Elsevier BV* pp. 227-242. 2023. DOI: <https://doi.org/10.1016/b978-0-323-95163-0.00006-2>
- [25] Benson, C., Obasi, I.C., Akinwande, D.V., and Ile, C., The impact of interventions on health, safety and environment in the process industry. *Heliyon*. 10(1), Art. e23604, 2024. DOI: <https://doi.org/10.1016/j.heliyon.2023.e23604>

**M.B. Vincés-Obando**, is Professor at the Faculty of Agro-Environmental Engineering at the Technical University of Manabí. She is BSc. Eng in Environmental Engineering, MSc. in Environmental and Energy Management, and is currently a PhD candidate in Environmental Sciences. Her research focuses on waste management, environmental sustainability studies, and environmental protection.  
ORCID: 0000-0002-3310-6202

**L.D. Balarezo-Saltos**, is support professor at the Faculty of Aquaculture and Marine Sciences, Sucre University of Peru. MSc. in Environmental Engineering and a MSc. in Integrated Management Systems for occupational risk prevention, quality, the environment, and corporate social responsibility. He also holds a degree in Occupational Health and Safety and is an internal auditor for the ISO 45001 standard. He is currently a PhD student in Environmental Sciences at the National University of Piura, Peru. His research focuses on environmental technologies, environmental management, and climate finance. He is a member of the Biodiversity and Ecology in Aquatic Systems Research Group.  
ORCID: 0000-0003-0259-7632

**C.A. Salas Macías**, He earned his degree in Agricultural Engineering from the Eloy Alfaro Lay University of Manabí (ULEAM) in 2005. In 2010, MSc. of Science in Tropical Agroforestry from the Tropical Agricultural Research and Higher Education Center (CATIE), and in 2011, a MSc. of Agricultural Administration and Marketing from ULEAM. In 2017, and Dr. of Philosophy in Environmental Engineering and Sciences from the National Agrarian University of La Molina (UNALM), Peru. He subsequently completed a postdoctoral fellowship at the University of Salamanca, Spain. He is currently pursuing complementary MBA studies in Data Science and Analytics, as well as a postdoctoral fellowship in Research Methodology and Scientific Production. He is a Senior Lecturer in the Faculty of Agroenvironmental Engineering at the Technical University of Manabí. His research focuses on the study of dry forests and sustainable production systems. He is a member of the FAGROCLIM research group and the DRYFLOR network.  
ORCID: 0000-0002-1641-1571

**F.R. Isea-León**, is Bsc. Eng. in Agricultural Engineering in 1995, with a Msc. Scientiarum in Food Science and Technology obtained in 2001 and PhD in Applied Sciences obtained in 2008. I worked at the Universidad Nacional Experimental Sur del Lago (UNESUR), located in Santa Barbara of Zulia, Venezuela, from January 2010 to June 2017. I held the position of Executive Director of the Foundation for the Development of Science and Technology in Zulia State (Territorial Unit Fundacite-Zulia), belonging to the Ministry of Science Technology from July 17, 2014 until May 30, 2017. Then from October 2017 to the present I exercise functions as Senior Lecturer I and researcher of the subjects Biochemistry, Microbiology, Nutrition of Aquatic Organisms and Degree Development II. Currently I also exercise management functions as Vice-Dean of Postgraduate Research and Linking of the Technical University of Manabí. My research areas of interest are the following: Physicochemical and microbiological quality of raw materials and feeds for aquatic organisms. Formulation and elaboration of alternative feeds for fish and shrimp nutrition. Evaluation of attractants in the feeding of aquatic organisms.  
ORCID: 0000-0002-3766-5108

**R.P. Panta-Vélez**, is a BSc. in Aquaculture and a MSc. in Sustainable Bioresource and Environmental Management. He is a professor and researcher with 17 years of experience in Aquaculture at the Technical University of Manabí. He is currently Vice Dean of the Renewable Natural Resources program. He specializes in Fisheries Biology, captive reproduction of organisms, mollusk farming, and water quality in aquaculture. He also serves as a technical advisor in water quality analysis for shrimp and fish farming in the province of Manabí, Ecuador. He is a member of the RIEAE Network, the AQUACIBUS Network, and the Ecuadorian Limnology Network, as well as the Biodiversity and Ecology of Aquatic Systems Research Group "BIOECOSYSTEM" at the Technical University of Manabí. He has participated in several research projects (UTM-Fundacyt, UTM-Provincial Development Agency of the province of Manabí, ADPM-AECI, UTM-Subsecretariat of Aquaculture, SARCE, RIEAE, UTM Research Institute) and is currently the director of the project "Evaluation of Water Quality and Biodiversity in the Chone River Estuary." He has been the advisor for 12 undergraduate theses, the reviewer for 13 undergraduate theses, and the advisor and co-advisor for 8 master's theses, all in the field of Aquaculture and Fisheries. He has published 11 papers in indexed journals and has been a speaker at several national and international conferences.

ORCID: 0000-0003-2969-0765

**D.E. Briones-Bermúdez**, is a BSc. in Clinical Laboratory Sciences in 2025. Currently pursuing a Master's degree in Quality and Patient Safety Management at the Pontifical Catholic University of Ecuador. Has worked in a private clinical laboratory, where he has gained experience in the collection and processing of biological samples as well as the use of equipment and techniques for clinical analysis. His areas of interest include laboratory procedures for clinical diagnosis, sample processing and analysis, and strengthening professional practice in healthcare settings, as well as risk management and regulatory compliance.

ORCID: 0009-0000-4499-480X