# Sindh (Pakistan) vs. New Jersey (United States):

# Nutrient Influence on Barnacle Populations and Pharmaceutical Efficiency

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## Abstract

Pakistan is home to a diverse variety of marine life, a lot of which has potential for use in the pharmaceutical industry. This research was carried out to investigate whether marine life in this area is viable for the development of locally-made medicine in order to increase employment and boost the economy. Acorn barnacles were chosen as a specimen, and soil compositions of Sindh, Pakistan, were compared with New Jersey, USA, as a standard.

The soil was tested and researched for pH, nitrogen, and phosphorus levels for both states. Further, to understand public perception of air quality, a survey was distributed via Google Forms.

Results from soil tests showed New Jersey as having higher pH, nitrogen, and phosphorus levels, as well as better air quality, all of which contribute to a potential for higher barnacle health, making acorn barnacles in New Jersey more viable for better antibiotics due to their antibacterial properties.

Conclusively, while the results suggest that while New Jersey has a better and healthier environment for acorn barnacles, Sindh still has some capacity to generate self-made antibiotics from its sources, as acorn barnacles are found to be overpopulating in both regions and are beneficial for use in pharmaceuticals, proving that if we can change some of the habitat factors in Sindh, advancements could be made reaching the level that New Jersey has exhibited.

## Introduction

Marine biology, which is the study of life in the oceans, is extremely crucial for not just understanding our saltwater bodies, but also for conserving the biodiversity in them. It provides various ways to manage marine resources sustainably, and research in this field has led to significant discoveries in medicine and biotechnology (Hu, 2011).

Pharmaceutical biotechnology plays a crucial role in driving innovations and advancements in drugs, diagnostic tools, and various forms of therapy. Multiple developments in this field, like gene therapy, novel drug design, and recombinant vaccines, have led to not just economic growth through the generation of new jobs but also improved the system of public healthcare and overall well-being, creating a better quality of life.

Pakistan, an agricultural country, is bordered by a warm-water sea with vast marine biodiversity. If used

correctly, the country could reap the benefits of its sea to improve the pharmaceutical industry. This in turn would boost the economy by generating jobs and reducing the costs of imports, taking benefits of every facet, from agriculture to aquaculture. Hence, it is important that Marine Natural Products (MNPs) be utilized in this region for making better, cheaper medicine. However, there seems to be a lack of research in this area. While some studies explored seaweeds, the research on the pharmaceutical potential of acorn barnacles in this region seems to be significantly scarce (Rizwi, 2005).

This research aims to tap into the potential of marine biology with respect to Pakistan's coastline as a harbor for pharmaceutical reserves. (Ahmad, 2025)

It was hypothesized that regions with lower population density, and as a result, lower pollution, would have a healthier environment for acorn barnacles to thrive for them to be used for the antibacterial properties in the pharmaceutical industry, whether in Sindh, Pakistan or New Jersey, USA as both the regions have a significant bloom in the size of acorn barnacles common to both areas (Moin, 2004).

The objective was to collect soil samples from New Jersey and test for pH and NPK, while researching soil composition in Sindh for the same. The air quality index in both regions was also checked. Together, these studies allowed for the evaluation of the potency of the soil to house healthy acorn barnacles for use in antibiotics due to their antimicrobial properties (Ramasamy, 2011).

## Methodology

Detailed experimental procedures, materials, and instrumentation were carried out to determine the pH, total nitrogen, and available phosphorus content of coastal soil samples. All steps were designed to ensure the accuracy, precision, and reproducibility of the results.

### 1. Materials and Reagents

All chemicals and reagents used were of analytical grade. Deionized (DI) water was used for all solution preparations unless otherwise specified.

- **For pH Analysis:** Deionized water ($H_2O$), standard buffer solutions.
- **For Total Nitrogen Analysis (Kjeldahl Method):** Concentrated sulfuric acid ($H_2SO_4$), potassium sulfate ($K_2SO_4$), copper sulfate ($CuSO_4 \cdot 5H_2O$), sodium hydroxide (NaOH) solution, boric acid ($H_3BO_3$) solution, indicator solution (a mixture of methyl red and bromocresol green), standard hydrochloric acid (HCl) solution.
- **For Available Phosphorus Analysis (Olsen Method):** Sodium bicarbonate ($NaHCO_3$) extracting solution (0.5 M, pH 8.5), activated charcoal, ammonium molybdate solution, ascorbic acid solution, antimony potassium tartrate solution, and standard phosphate solutions.

### 2. Instrumentation and Equipment

- **General Equipment:** Analytical balance, drying oven, desiccator, sieve (2 mm mesh), mortar and pestle, beakers, volumetric flasks, funnels, filter paper.
- **For pH Analysis:** pH meter with a glass electrode.
- **For Total Nitrogen Analysis:** Kjeldahl digestion unit, Kjeldahl distillation unit, titration

apparatus (burette, conical flasks).

- **For Available Phosphorus Analysis:** Spectrophotometer (UV-Vis), shaker or reciprocating flask shaker, centrifuge.

## 3. Experimental Procedures

### Sample Preparation

1. **Collection:** Soil samples were collected from three distinct sites along the coastline. At each site, three replicates were collected from a depth of 0-15 cm.
2. **Drying:** Samples were air-dried at room temperature, then placed in a drying oven at a constant temperature to remove moisture.
3. **Grinding & Sieving:** Dried soil was gently crushed and sieved through a 2 mm mesh. The sieved soil was stored in labeled plastic bags in a desiccator until analysis.

### A. Soil pH Measurement

1. **Preparation:** A known weight of the prepared soil was placed in a beaker. 2. **Slurry Formation:** A specific volume of deionized water was added to create a soil-water slurry with a standard ratio (e.g., 1:2). The mixture was stirred and allowed to stand for a specified time.
3. **Measurement:** The pH meter was calibrated using standard buffer solutions. The electrode was then immersed in the slurry, and the pH reading was recorded once it stabilized.

### B. Total Nitrogen Determination (Kjeldahl Method)

1. **Digestion:** A known weight of the soil was placed in a Kjeldahl flask. A catalyst mixture and a specific volume of concentrated $H_2SO_4$ were added. The flask was heated on the digestion unit until the solution became clear.
2. **Distillation:** The digested sample was transferred to the distillation unit. A sodium hydroxide solution was added to release ammonia gas ($NH_3$). The $NH_3$ was distilled and captured in a receiving flask containing boric acid and an indicator solution.
3. **Titration:** The resulting solution was titrated with a standard hydrochloric acid (HCl) solution until the endpoint was reached. The volume of HCl consumed was recorded. 4. **Calculation:** The total nitrogen content was calculated using the following formula:

$$\text{TotalN}(\%) = W(Vs - Vb) \times NHCl \times 1.4007 \times 100$$

Where Vs is the volume of HCl used for the sample (mL), Vb is the volume for the blank (mL), NHCl is the normality of the acid solution, and W is the weight of the soil sample (g).

### C. Available Phosphorus Determination (Olsen Method)

1. **Extraction:** A known weight of soil was placed in a flask. A specific volume of the Olsen extracting solution was added, and the mixture was shaken for a set period (e.g., 30 minutes).
2. **Filtration:** The suspension was filtered to obtain a clear extract.
3. **Color Development:** A known volume of the extract was mixed with a series of reagents to form a blue-colored complex.

4. **Spectrophotometric Measurement:** The absorbance of the colored solution was measured at a specific wavelength using a spectrophotometer. The concentration was determined by comparing the absorbance to a standard curve.

### 4. Estimated Timeline

This is a general estimate; actual times will vary depending on the lab and resources.

- **Sample Collection:** 1 day
- **Sample Preparation (Drying & Sieving):** 3-4 days
- **pH Analysis:** 1 day
- **Total Nitrogen Analysis:** 3-4 days (Digestion, Distillation, Titration)
- **Available Phosphorus Analysis:** 2-3 days (Extraction, Color Development, Measurement)
- **Data Analysis and Figure Preparation:** 1-2 days

Further, surveys were carried out for both Sindh and New Jersey for air quality, and the results were compared and matched with the corresponding air quality index for the two states. Google Forms was used to gather public perceptions on air quality, and the age range was carefully selected from 1990 onwards till 2025. The survey included questions on personal perception of local air quality, observed health effects, and any precautions taken to adapt to the air quality. The survey was distributed to get a sense of local community opinions, and 30 responses were obtained from the survey for Sindh.

## Results

### New Jersey, United States:

**pH Value: 7.1**

- The ideal water pH for most plants and marine animals in New Jersey is slightly acidic, generally between 6.0 and 7.0. While most plants thrive in this range, some plants, like azaleas and rhododendrons, prefer more acidic conditions, and other marine animals prefer this too, according to the University of Minnesota Twin Cities.

**Nitrogen Value: 60 ppm**

- For many purposes, a water nitrate-nitrogen (NO3-N) level in the range of 50 to 70 ppm is often cited as a sufficient range for animal growth, according to the New Jersey Agricultural Experiment Station.

**Phosphorus Value: 50 ppm**

- Research suggests that a water test value between 40 and 55 ppm (parts per million) phosphorus is considered optimal for agronomic crops and marine animal inclination, according to the New Jersey Agricultural Experiment Station.

**Sindh, Pakistan:**

- **pH Value: 6.2**
    - The average pH of Sindh's coastal water typically ranges from slightly acidic to alkaline, with values often above 6.0. Studies indicate that the pH can vary from 6.0 to 8.0, with an average around 6.5, according to ResearchGate. While not necessarily the ideal conditions for plants to thrive, acorn barnacles show adaptability over a range of pH values. A higher pH allows for sperm activation as well in acorn barnacles, contributing to a higher reproduction rate.

- **Nitrogen Value: 30 ppm**
    - The average total nitrogen content was found to be **0.047%** in the topsoil (0-15 cm) and **0.028%** in the subsoil (15-30 cm). The paper notes that these levels are considered low, as 77% of the water samples were poor in total nitrogen, according to ResearchGate. Since acorn barnacles are filter feeders, they depend on sweep plankton and other microscopic food particles for their diet. Low nitrogen levels in the water could have an indirect impact, as these nutrients are essential for phytoplankton growth, which are a major component of the plankton that barnacles eat.

- **Phosphorus Value: 30 ppm**
    - Similar to nitrogen, available phosphorus is also considered **low to deficient**. Research papers report values in the range of **20 to 35 ppm**, according to Journal of Applied Sciences. Low phosphorus levels also have an impact on phytoplankton growth, which could lead to a decrease in the food source for acorn barnacles, potentially affecting their growth and survival.

The results from the surveys carried out for both Sindh and New Jersey for air quality were compared and matched with the corresponding average air quality index for the two states.

- **Sindh**
    - The air quality was ranked as moderate in the survey from people in different areas of Sindh, indicating that the air quality varied in different areas, as the highest rating for it was 5 out of 10.
    - The use of air purifiers was found to be little to none, as 60% of the people did not use them, and 36.7% showed some, but not many, households in their areas did use air purifiers. This lack of use depicts that the air quality can be healthy to moderate for this state.
    - When asked about any negative impacts on health, most of the people showed a 0 out 10, while only 4 responses out of the 30 ranked the impact as a 6 out of 10. This shows that the air quality has little to no negative effect on people's health.
    - 19 responses out of 30 showed the public as taking no precautions to adapt to their air quality when asked to write about it briefly in the form, while 5 people chose to wear face masks as an active precaution from any harm. This also shows that the air quality

is moderate to healthy, since the general public does not deem it necessary to take protective measures.

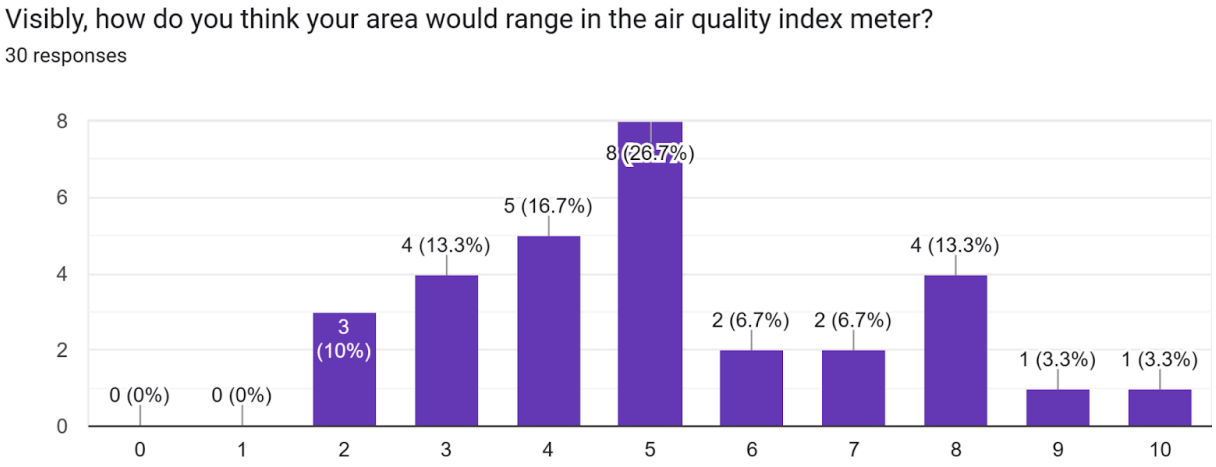


**Figure 1. (Visibility AQI per Sindh, Pakistan)**

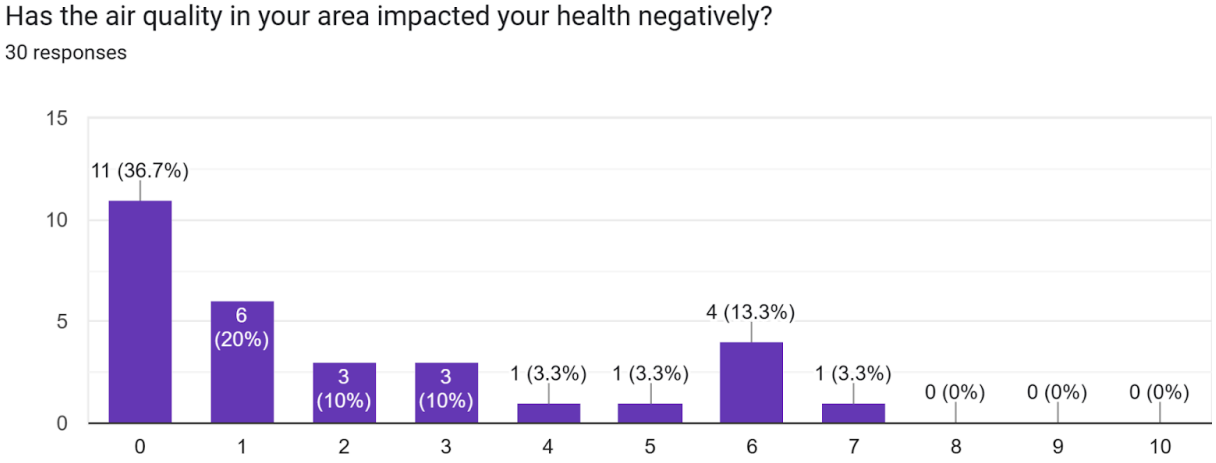


**Figure 2. (Health Impacts AQI per Sindh, Pakistan)**

The average air quality for Sindh was shown to be 91.2, according to IQAir.com, and 70 for Karachi, according to IQAir.com.

- **New Jersey**
  - The air quality was ranked as good in the survey from people in different areas of New Jersey, indicating that the air quality was pretty consistent around the state. ○ The use of air purifiers was found to be little to none. This lack of use depicts that the air quality is very healthy for this state.
  - Visibly, it was noted that a higher percentage said air quality was 3/10, which is lower than the amount Sindh's population put it to be.

- When asked about any negative impacts on health, most of the people showed a 0 out of 10. This shows that the air quality has little to no negative effect on people's health.

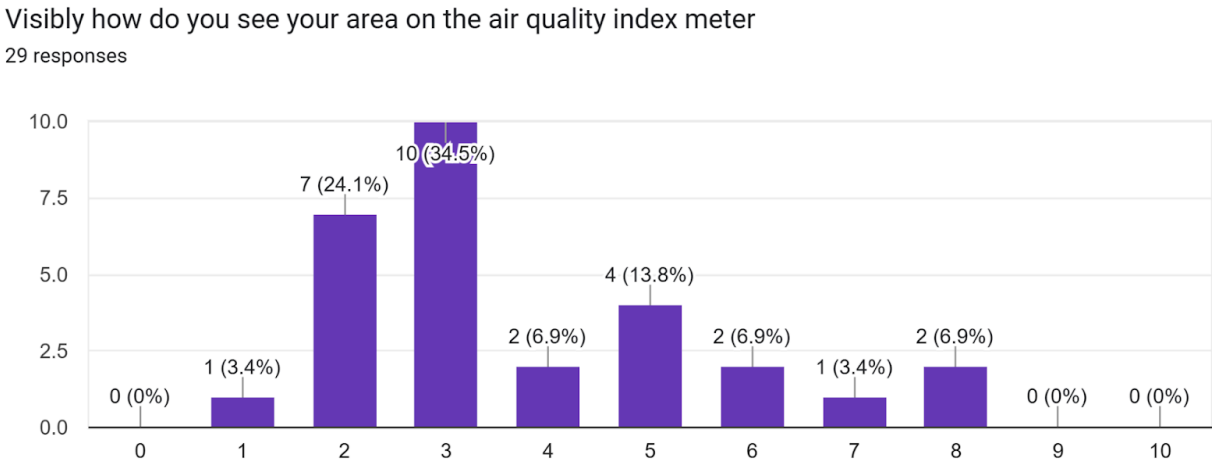


**Figure 3. (Visibility AQI per New Jersey, United States)**

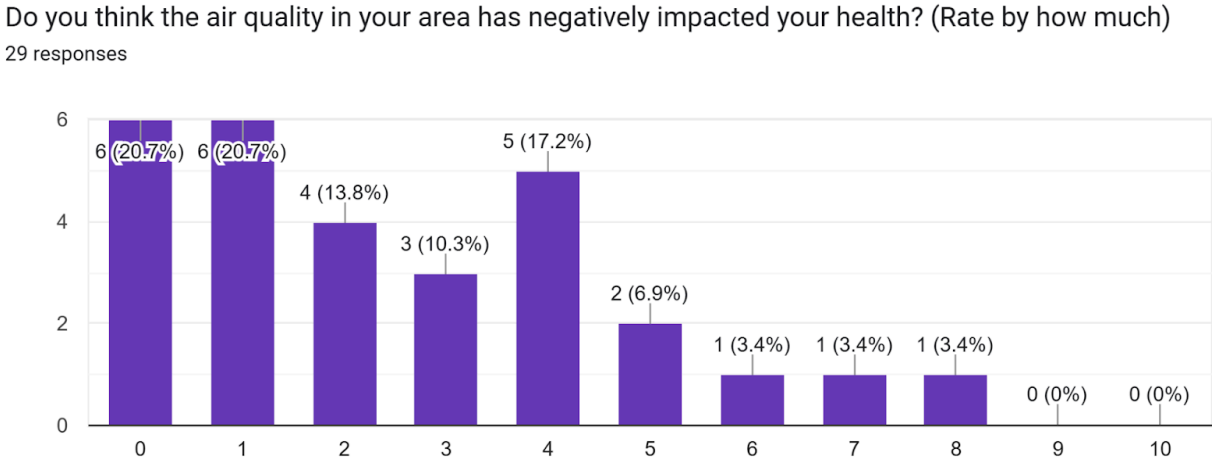


**Figure 4. (Health Impacts AQI per New Jersey, United States)**

The average air quality for New Jersey is 60, according to AirNow.gov, and 55 for Toms River, according to AirNow.gov.

## Discussion

Overall, each of the tests pinpoints to the fact that New Jersey, United States, has a healthier, more habitable area for Acorn Barnacles. To break it down: the most ideal values for water samples have high pH (to allow for quicker sperm activation and higher reproduction), a high nitrogen level (to allow for good nutrients to provide food sources), and a high phosphorus content (to allow for more vitamins for functioning). Due to the fact, New Jersey, specifically Toms River, has a higher pH value of 7.0 compared to Karachi, Sindh, with a value of 6.2 and higher nitrogen and phosphorus content at 60 ppm and 50 ppm respectively, this location of Toms River is considered the most habitable area for a greater population of Barnacles to thrive. Additionally, when relating this to the air quality index (AQI) the

average AQI in Toms River is 55, which is healthier for Barnacles than Karachi's AQI (70). As well, according to the surveys given to a sample population of n=25 to 30 per area, results show that Toms River's population agrees with a better AQI than Karachi's population. This habitat in NJ proves to be healthier for a great population of Acorn Barnacles, which allows for antibiotics to be used in pharmaceuticals, ultimately proving that Toms River, New Jersey, has more advanced pharmaceuticals than Karachi, Sindh.

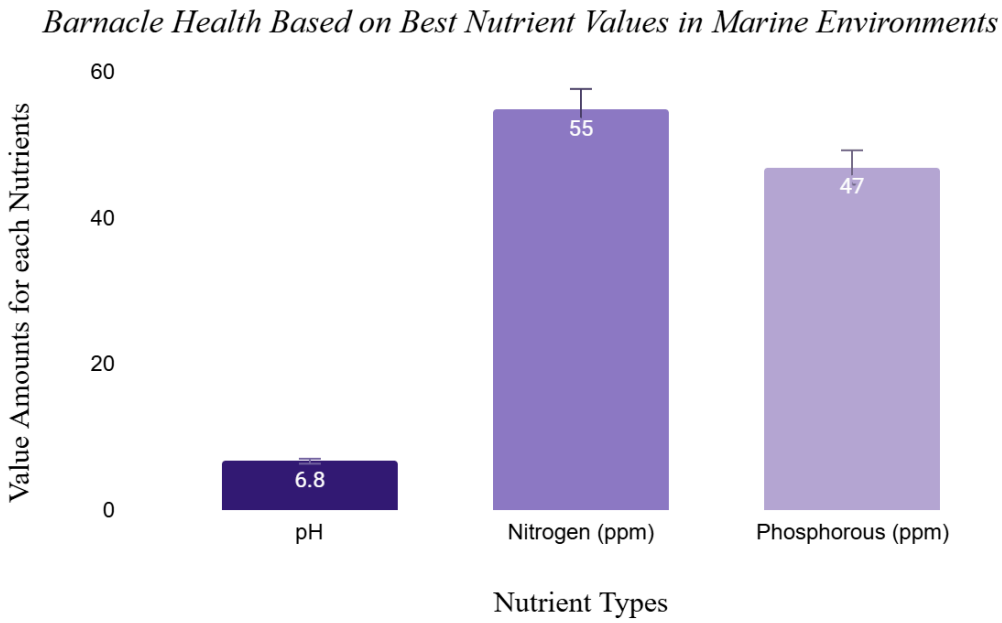


**Figure 5. (Standard Nutrient Values for Barnacle Health)**

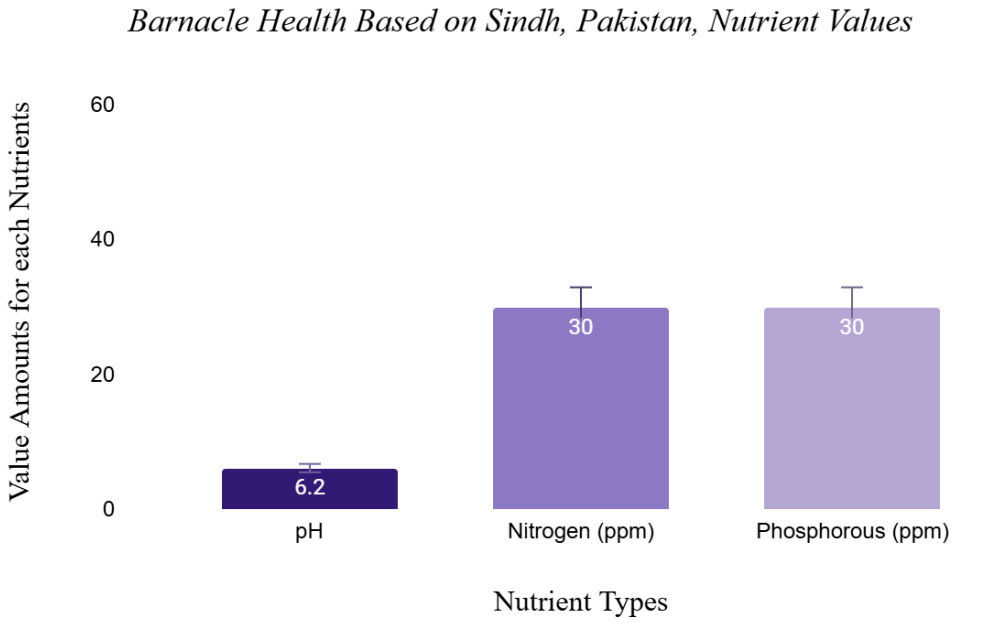


**Figure 6. (Standard Nutrient Values for Sindh, Pakistan)**

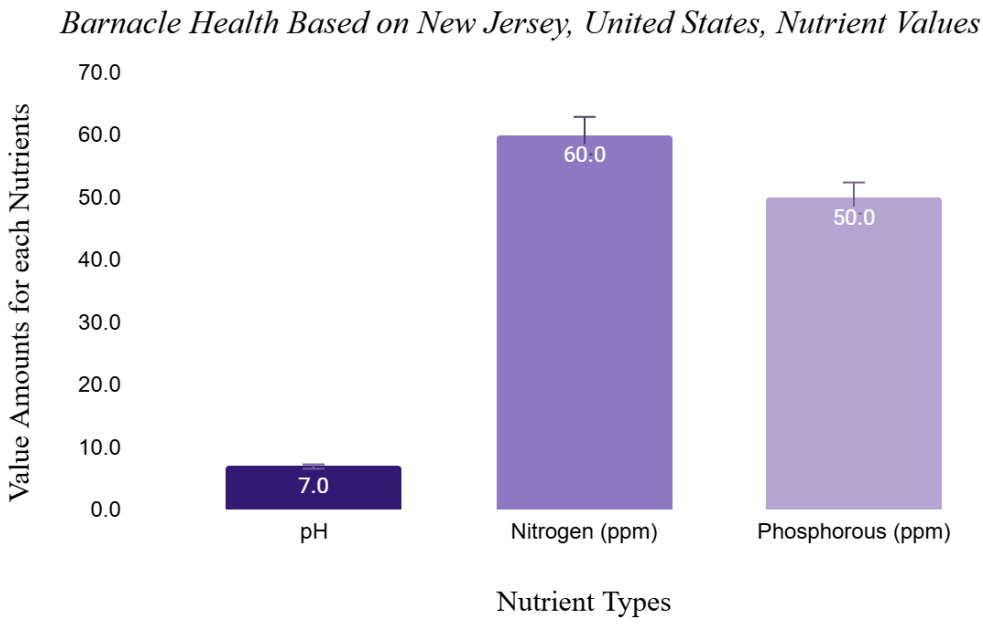


**Figure 7. (Standard Nutrient Values for New Jersey, United States)**

## Conclusion

Based on the key findings from both New Jersey, USA, and Sindh, Pakistan, and comparisons to compare environments for acorn barnacles to thrive in for pharmaceuticals, New Jersey was found to have healthier soil composition and air quality. The soil pH was higher for better barnacle reproduction, and while higher nitrogen and phosphorus levels in soils like that of New Jersey do not influence barnacle growth as they are filter feeders and do not take in nutrients directly from their soil, it may still have an indirect impact as they depend on phytoplankton for their diet, which take nutrients from the soil.

Sindh, Pakistan, was found to have a slightly acidic environment with lower levels of nitrogen and phosphorus, which means that while it is not an ideal environment for acorn barnacles to thrive, the area is still viable for barnacle growth and potential use in pharmaceuticals.

Further, the results from the survey for air quality showed New Jersey as having healthier air quality than Sindh, signifying better acorn barnacle growth.

Ultimately, as shown in the graphs below, barnacle health, which is shown higher in New Jersey rather than Sindh, has led to a higher total revenue of pharmaceuticals in NJ, USA, rather than Sindh, Pakistan, proving the hypothesis accurate. This information could be used to help change the habitat and environmental factors of Sindh, Pakistan, to allow for more efficient uses of pharmaceuticals and overall a better lifestyle in this country.

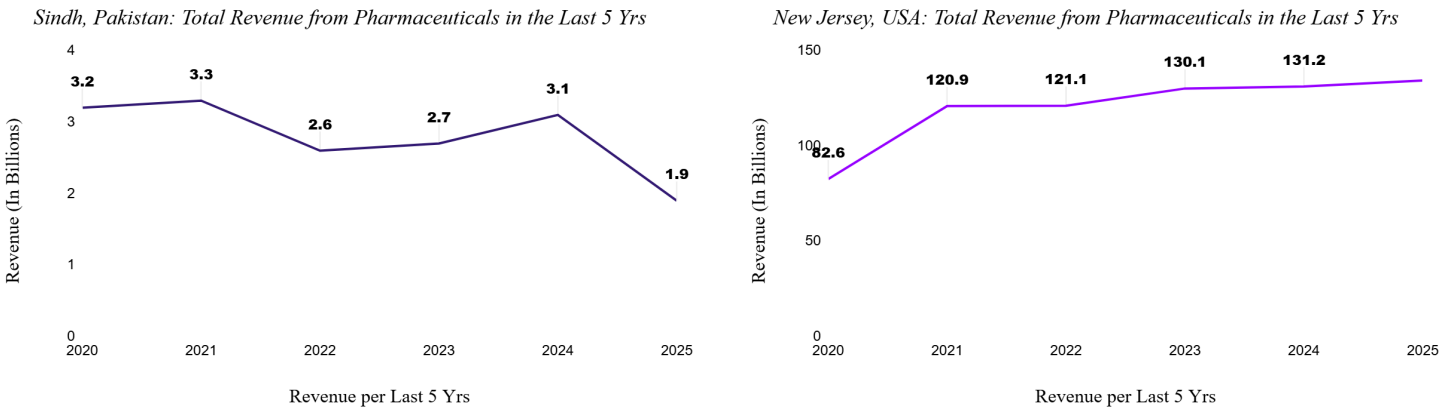


**Figure 8. (Revenue in Pharmaceuticals for Sindh, Pakistan vs. New Jersey, United States)**

## Acknowledgements

I would like to acknowledge my family for pushing me to do better, my friends for supporting me, my professors for providing me with crucial data on Sindh's coastline, and all of the participants who were there to complete an instrumental part of the experiment, the survey. I would also like to thank the organization, Insightful Leadership and Research Fellowship (ILRF). Lastly, I would like to thank my mentor, Alexandra Kanterezhi-Gatto, for her help in conducting and guiding me throughout this process! Thank you!

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## Author Biographies

**Ashna Kashif** is a freshman at Bahria University of Health Sciences whose love for her degree in Biotechnology has led her here to start exploring this vast field in order to expand her horizons and find what exactly she loves and pursue it further. Ashna enjoys writing in literature, and this is her first time formally putting out writing in a research aspect. She is so excited alongside her amazing mentor, Alex!

**Alexandra Kanterezhi-Gatto** is a sophomore in high school at a specialized Marine Academy who loves to participate in anything research- related like certain science fairs, association competitions, STEM matches, or programs like these. Alex is so excited to present the research she conducted with her fellow mentee, Ashna! Thank you so much for your time and consideration.