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Spatial Variation of Microplastic Concentrations in Surface Water Bodies of Tehsil Pattoki

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Abstract:

Microplastics are persistent environmental contaminants increasingly detected in freshwater ecosystems. Their concentrations can vary considerably among locations because of differences in water movement, surrounding land use, waste disposal, and proximity to human activities. This study examined the spatial variation of suspected microplastic concentrations in selected water bodies of Tehsil Pattoki, Punjab, Pakistan, using data generated in the author's undergraduate thesis. Twelve one-litre water samples were collected from filtration plants, drinking-water supplies, groundwater, a swimming pool, null water, running canal water, standing surface water, swamp water, and tap water. Samples were processed through stacked sieves, drying, density separation with 5M sodium chloride solution, filtration, and stereomicroscopic examination at 40× magnification. Suspected microplastics were detected in four samples at concentrations of 6, 10, 12, and 15 particles per litre, whereas eight samples contained no visually identifiable particles. Standing swamp water at Chak 34 Mundaiki contained the highest concentration, followed by standing surface water at the University of Veterinary and Animal Sciences, running canal water at Kashif Chowk, and swimming-pool groundwater near National Highway 5. The total particle count was 43, with an overall mean of 3.583 particles per litre and a standard deviation of 5.407. Microfibres, microbeads, and microfragments were the main morphological forms observed. The spatial pattern indicated greater contamination in exposed surface and recreational waters than in filtration-plant, tap-water, and several groundwater samples. The findings provide baseline evidence of heterogeneous microplastic distribution in Pattoki but require confirmation through expanded seasonal sampling and polymer-specific spectroscopy.

Keywords: *microplastics, spatial variation, surface water, Tehsil Pattoki, freshwater pollution, canal water, standing water, Punjab*

Introduction

Plastic materials are used worldwide because of their low cost, durability, lightweight structure, flexibility, and suitability for numerous applications. They are essential components of packaging, agriculture, clothing, cosmetics, transport, construction, electrical equipment, medicine, and household products. However, the durability that makes plastic economically useful also allows discarded materials to persist in natural environments. Large plastic materials gradually break down through sunlight, oxidation, mechanical abrasion, temperature variation, water movement,

and biological activity. This process produces progressively smaller plastic particles. Particles measuring less than 5 mm are commonly categorized as microplastics. They may occur as fibres, fragments, films, beads, pellets, or foams and vary in size, colour, density, and polymer composition (Castro et al., 2018; Zhang et al., 2021). Primary microplastics are manufactured at a microscopic size for use in cosmetics, medicines, personal-care products, industrial abrasives, and plastic production. Secondary microplastics result from the environmental fragmentation of larger items such as bottles, shopping bags, packaging materials, agricultural sheets, synthetic textiles, and household waste (Efimova et al., 2018). Microplastics can enter freshwater ecosystems through domestic wastewater, agricultural runoff, industrial discharge, atmospheric deposition, drainage networks, and direct littering. Rivers and canals transport particles over long distances, while ponds, wetlands, reservoirs, and standing water bodies may retain them. The distribution of microplastics is rarely uniform. Concentrations can vary according to the location and characteristics of a water body. Water flow, sediment composition, vegetation, depth, rainfall, surrounding land use, population density, and distance from pollution sources can influence particle occurrence. Flowing water can transport microplastics downstream, whereas standing water can function as an accumulation zone. Groundwater may receive particles through soil infiltration, damaged wastewater systems, or contaminated recharge. Filtration plants may remove some particles, although their effectiveness depends on treatment technology and particle size. Tehsil Pattoki contains urban settlements, villages, agricultural land, irrigation canals, groundwater resources, filtration plants, recreational facilities, and standing surface waters. The diversity of these environments creates different potential microplastic sources and transportation pathways. The present study evaluated the spatial variation of suspected microplastic concentrations across twelve sampling locations in Pattoki. It identified sites with relatively high concentrations, compared contamination among water-source categories, and considered possible environmental factors influencing the observed distribution.

Study Area and Sampling Framework:

Twelve samples were collected from selected locations across Tehsil Pattoki on 12 June 2022. Sampling was conducted between 9:13 a.m. and 1:33 p.m. Every sample consisted of approximately one litre of water collected in a separate glass bottle. The sites represented a range of freshwater and water-supply environments. They included filtration plants, drinking groundwater, swimming-pool water, null water, running canal water, standing surface water, swamp water, and tap water. The geographical coordinates, altitude, address, sampling source, and surrounding distribution area were recorded. Google Earth and Google Maps were used in the thesis to identify sampling locations and coordinates.

Table 1Locations and Microplastic Concentrations

Sample	Sampling location and source	Coordinates	MPs/L
S-1	Shadman Colony filtration plant, groundwater	31°1′15″N, 73°50′45″E	0
S-2	Halla Road drinking water, groundwater	31°1′58″N, 73°50′27″E	0
S-3	Moon Light Swimming Pool, NH-5	31°2′18″N, 73°50′25″E	6

Sample	Sampling location and source	Coordinates	MPs/L
S-4	Al-Noor City null water, NH-5	31°2′3″N, 73°50′57″E	0
S-5	Main Bazar filtration plant	31°1′9″N, 73°50′57″E	0
S-6	Kashif Chowk running canal water	31°0′48″N, 73°51′44″E	10
S-7	Purani Mandi filtration plant	31°1′0″N, 73°51′4″E	0
S-8	Chak 34 Mullan Wala null water	31°2′36″N, 73°51′49″E	0
S-9	UVAS Pattoki standing surface water	31°3′41″N, 73°51′57″E	12
S-10	Chak 34 Mundaiki standing swamp water	31°3′28″N, 73°51′9″E	15
S-11	Mohalla Malikpura filtration plant	31°1′33″N, 73°51′31″E	0
S-12	Al Hamad Town tap water	31°1′32″N, 73°51′43″E	0

The sampling network extended across different parts of Pattoki at altitudes ranging approximately from 623 to 652 feet. This spatial coverage permitted a preliminary comparison of microplastic occurrence among different water-source types. Each sample was passed through stacked sieves arranged according to openings of ≥2.0 mm, ≥0.5 mm, ≥0.35 mm, and 0.5 µm. Materials retained by the sieves were placed on filter paper and dried. The dried materials were mixed with 30 ml of 5M sodium chloride solution and stirred for three minutes. The mixture was placed in a density-separation apparatus overnight. Lightweight materials in the upper layer were filtered, dried, and examined under a stereomicroscope at 40× magnification. Suspected particles were characterized according to their visible size, shape, and colour. The main forms identified were microfibres, microbeads, and microfragments. The concentration was expressed as the number of suspected particles per litre.

Spatial Patterns of Microplastic Concentration:

The results showed substantial spatial variation among the twelve sites. Suspected microplastics were present in only four samples, whereas eight samples contained no visually identifiable particles. Sample S-10, collected from standing swamp water at Chak 34 Mundaiki, had the highest concentration at 15 particles per litre. Sample S-9, obtained from standing surface water at the UVAS Pattoki campus, contained 12 particles per litre. Sample S-6, collected from running canal water near Kashif Chowk, contained 10 particles per litre. Sample S-3, representing swimming-pool groundwater near National Highway 5, contained 6 particles per litre. Together, these four locations accounted for all 43 suspected particles recorded during the study. The overall mean was 3.583 particles per litre, while the standard deviation was 5.407. The relatively large standard deviation compared with the mean demonstrates considerable spatial variability. The highest-concentration site contained 2.5 times as many particles as the lowest positive site. Moreover, the eight zero-count locations contrasted strongly with the four positive sites. This pattern demonstrates that microplastic contamination was localized rather than uniformly distributed

across Pattoki. Standing water sites accounted for 27 of the 43 particles, representing approximately 62.8% of the total observed load. Running canal water accounted for 10 particles, or approximately 23.3%, while swimming-pool water contributed six particles, or approximately 14.0%. These percentages describe the distribution of particles within the limited study sample. They should not be interpreted as estimates of the overall microplastic contribution of all water-source categories in Pattoki because only one or a few samples represented each category. The concentration in filtration-plant, drinking-water, null-water, and tap-water samples was zero according to visual microscopic examination. These results suggest that exposed surface waters were more likely to contain detectable particles than controlled water-supply sources during the sampling period.

Influence of Water Source and Environmental Conditions:

The spatial distribution of microplastics can be influenced by the physical characteristics of a water source. Standing water generally has limited circulation and reduced flushing. Consequently, plastic particles entering these environments can remain trapped for longer periods. The high concentration in the Chak 34 Mundaiki swamp-water sample may have resulted from particle retention among sediment, vegetation, organic matter, and surface litter. Swamp-like environments can accumulate materials transported by rainfall, runoff, wind, animals, and nearby human activities. The standing surface water at UVAS Pattoki also contained a relatively high concentration. Standing water on institutional or agricultural land may receive litter, drainage, soil runoff, synthetic fibres, and fragments from surrounding activities. The running canal-water site near Kashif Chowk contained 10 particles per litre. Irrigation canals can receive microplastics from agricultural fields, household drainage, roadside litter, textile fibres, plastic packaging, fertilizer bags, pesticide containers, and damaged irrigation materials. Flowing canal water does not necessarily retain particles at the collection point. It may transport contamination from upstream areas. Therefore, the particles observed near Kashif Chowk could have originated locally or entered the canal at another location. The swimming-pool sample contained six particles per litre despite being identified as groundwater-derived water. Possible sources include synthetic swimwear, cleaning materials, pool equipment, airborne particles, surrounding plastic products, or contamination introduced by users. The zero counts recorded at filtration plants may indicate some removal of larger microplastic particles during water treatment. However, the effectiveness of filtration was not directly evaluated. Small particles below the analytical detection range may have remained present Groundwater is generally less directly exposed to surface litter than canals and ponds. Nevertheless, microplastics may enter groundwater through contaminated recharge, wastewater leakage, soil infiltration, or damaged sewage systems. More sensitive analytical methods are required to evaluate this possibility.

Environmental Sources and Ecological Implications:

The identified microfibres, microbeads, and microfragments indicate multiple pollution sources. Microfibres may originate from polyester, nylon, acrylic, synthetic ropes, carpets, and clothing. Washing synthetic textiles releases fibres that can pass through household drainage and enter freshwater systems. Microbeads are generally associated with cosmetics, personal-care products, cleaning materials, medicines, industrial abrasives, and plastic manufacturing. Their small size enables them to pass through some wastewater-treatment systems. Microfragments develop through the degradation of larger plastic products. In Pattoki, possible sources include bags, bottles, food packaging, agricultural films, fertilizer sacks, pesticide containers, disposable

products, footwear, and construction materials. Land use surrounding a sampling location can influence the type and quantity of particles entering water. Agricultural locations may receive degraded plastic mulch and chemical-product packaging. Urban sites may receive packaging waste, synthetic textile fibres, road runoff, and household wastewater. Microplastics can be ingested by zooplankton, molluscs, aquatic insects, crustaceans, fish, birds, and mammals. Small aquatic organisms may mistake particles for food, allowing plastics to enter food chains (Botterell et al., 2019). Particle ingestion may cause reduced feeding, false satiation, digestive obstruction, tissue damage, inflammation, oxidative stress, and altered physiological functions. Hamed et al. (2019) reported changes in blood biomarkers in juvenile Nile tilapia exposed to microplastics. Microplastics may also transport dyes, plasticizers, stabilizers, metals, and organic pollutants. These substances may be released from the plastic or adsorbed from surrounding water. Their potential effects therefore involve both particle exposure and associated chemicals. The present research did not directly measure microplastic ingestion by organisms or evaluate human-health effects. The findings should consequently be interpreted as evidence of environmental occurrence rather than evidence of specific health outcomes.

Statistical Interpretation, Limitations, and Recommendations:

The mean concentration across the twelve samples was 3.583 particles per litre. The reported standard deviation of 5.407 reflected the strong difference between the eight zero-count sites and the four contaminated sites. The thesis also compared two geographical groups and reported a correlation coefficient of −0.399. One-way analysis of variance produced $F(1,10) = 0.93$ and $p = 0.35$, indicating no statistically significant difference between those groups. However, the rural and urban labels presented in the thesis's site-description table differ from those shown in its statistical grouping table. For this reason, the present spatial analysis emphasizes verified site locations and water-source categories instead of assigning new conclusions based on the inconsistent labels. The study was based on twelve samples collected on a single day. It therefore cannot represent seasonal changes associated with rainfall, flooding, irrigation, temperature, or water flow. Every location should be sampled repeatedly during different seasons. Only one litre of water was analysed from each location, and site replicates were not reported. Larger sample volumes and multiple replicates would provide more reliable estimates and help distinguish persistent contamination from temporary variation. Visual identification under a stereomicroscope may misclassify natural fibres or other particles as plastics. Future investigations should use FTIR or Raman spectroscopy to verify polymer composition. Procedural blanks, field blanks, filtered reagents, covered glassware, and non-synthetic laboratory clothing should be incorporated to control contamination. Samples of sediment, plankton, aquatic plants, invertebrates, and fish should also be examined. Future studies should develop a geographically balanced sampling network covering upstream and downstream canal sites, industrial areas, urban drains, villages, agricultural fields, filtration plants, ponds, and wetlands. Geographic information systems could then be used to map contamination hotspots and potential sources.

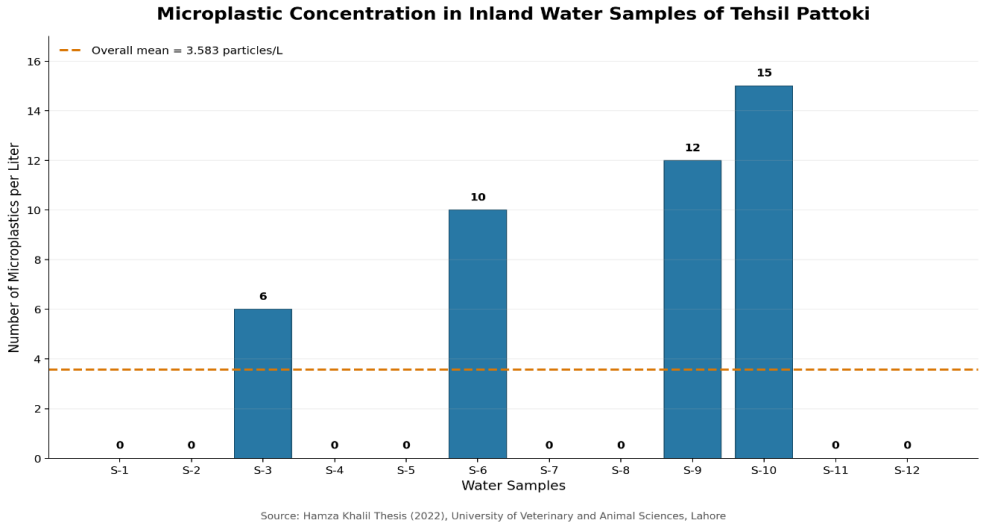


Figure 1: Spatial Variation in Microplastic Concentration

Summary

The study examined spatial variation in suspected microplastic concentrations across twelve water sources in Tehsil Pattoki. Samples were obtained from filtration plants, groundwater, drinking water, a swimming pool, canal water, standing surface water, swamp water, null water, and tap water. Samples were processed through stacked sieves, drying, sodium chloride-assisted density separation, filtration, and stereomicroscopic examination. Microfibres, microbeads, and microfragments were the major particle forms identified. Microplastics were detected in four locations. The concentrations were 6 particles per litre in swimming-pool water, 10 particles per litre in running canal water, 12 particles per litre in standing surface water, and 15 particles per litre in standing swamp water. The eight remaining samples had zero visually detected particles. Overall, 43 suspected particles were documented, with a mean of 3.583 particles per litre and a standard deviation of 5.407. Standing water samples accounted for 27 particles, representing approximately 62.8% of the total observed count. These results indicate that exposed and slow-moving surface waters may function as microplastic accumulation areas. The findings provide baseline evidence of heterogeneous microplastic contamination in Pattoki. Larger seasonal studies, repeated site sampling, quality-control procedures, sediment analysis, ecological assessment, GIS mapping, and spectroscopic polymer confirmation are recommended.

References

Batel, A., Borchert, F., Reinwald, H., & Braunbeck, T. (2019). Microplastic accumulation patterns and transfer of benzo[a]pyrene to adult zebrafish gills and zebrafish embryos. *Environmental Pollution, 235*, 918–930.

Botterell, Z. L. R., Beaumont, N., Dorrington, T., Steinke, M., Thompson, R. C., & Lindeque, P. K. (2019). Bioavailability and effects of microplastics on marine zooplankton: A review. *Environmental Pollution, 245*, 98–110.

Campanale, C., Massarelli, C., Savino, I., Locaputo, V., & Uricchio, V. F. (2020). A detailed review study on potential effects of microplastics and additives of concern on human health. *International Journal of Environmental Research and Public Health, 17*(4), 1212.

Castro, R. O., da Silva, M. L., & de Araújo, F. V. (2018). Review on microplastic studies in Brazilian aquatic ecosystems. *Ocean & Coastal Management, 165*, 385–400.

Ding, L., Mao, R. F., Guo, X., Yang, X., Zhang, Q., & Yang, C. (2019). Microplastics in surface waters and sediments of the Wei River in northwest China. *Science of the Total Environment, 667*, 427–434.

Efimova, I., Bagaeva, M., Bagaev, A., Kileso, A., & Chubarenko, I. P. (2018). Secondary microplastics generation in the sea swash zone with coarse bottom sediments: Laboratory experiments. *Frontiers in Marine Science, 5*, 313.

Hamed, M., Soliman, H. A. M., Osman, A. G. M., & Sayed, A. E. D. H. (2019). Assessment of the effects of exposure to microplastics in Nile tilapia early juveniles using blood biomarkers. *Chemosphere, 228*, 345–350.

Khalil, H. (2022). *Characterization of microplastics in some inland water bodies at Tehsil Pattoki, Punjab, Pakistan* [Undergraduate thesis, University of Veterinary and Animal Sciences, Lahore].

Lehtiniemi, M., Hartikainen, S., Näkki, P., Engström-Öst, J., Koistinen, A., & Setälä, O. (2018). Size matters more than shape: Ingestion of primary and secondary microplastics by small predators. *Food Webs, 17*, e00097.

Masura, J., Baker, J., Foster, G., & Arthur, C. (2015). *Laboratory methods for the analysis of microplastics in the marine environment: Recommendations for quantifying synthetic particles in waters and sediments*. NOAA Technical Memorandum NOS-OR&R-48.

Nelms, S. E., Galloway, T. S., Godley, B. J., Jarvis, D. S., & Lindeque, P. K. (2018). Investigating microplastic trophic transfer in marine top predators. *Environmental Pollution, 238*, 999–1007.

Zhang, K., Hamidian, A. H., Tubić, A., Zhang, Y., Fang, J. K. H., Wu, C., & Lam, P. K. S. (2021). Understanding plastic degradation and microplastic formation in the environment: A review. *Environmental Pollution, 274*, 116554.