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Posted Date: 19 February 2026

doi: 10.20944/preprints202602.1343.v1

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 doi:10.20944/preprints202602.1343.v1

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Effect of Polystyrene Microplastics Exposure on Blood Parameters in Mice

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Abstract

Microplastics are emerging environmental contaminants capable of crossing epithelial barriers and circulating systemically, potentially affecting organisms, including humans. This study investigated the hematological and biochemical effects of subchronic oral exposure to polystyrene microplastics (PS-MPs) in male Swiss albino mice. Animals received 1 μm PS-MPs in drinking water at 0.01 mg/day for four weeks, followed by a two-week recovery period. Blood samples were collected weekly for analysis. PS-MP exposure increased white blood cell, lymphocyte, and granulocyte counts, with a reduced monocyte percentage after the first week, and a significant rise in platelet count by week six. Elevated alanine and aspartate aminotransferase activities indicated hepatic injury, while altered urea and creatinine levels suggested renal impairment. No significant recovery was observed after PS-MP withdrawal. These findings demonstrate that subchronic oral PS-MP exposure induces inflammatory responses and disrupts liver and kidney function.

Keywords: blood; mice; polystyrene; toxicokinetics

1. Introduction

In recent years, microplastic pollution has emerged as a potential threat to both the ecosystem and human health [1]. Microplastics (MPs) are defined as plastic particles ranging in size from 1 μm to 5 mm with primary and secondary origins [2]. They are widespread across all components of the environment: air, water, and soil. From these sources, they may enter living organisms primarily through the consumption of food and water, as well as inhaled air [3]. Moreover, MPs can accumulate in organs and tissues, and be present in biological fluids, potentially causing harmful effects on organisms, including humans [2,4,5].

The detection of MPs in human blood, firstly by Leslie et al. [6], confirmed their ability to cross epithelial barriers and circulate systemically. The most probable route for MPs to enter the bloodstream is through ingestion and absorption in the gut [7,8]. Some pathologies, such as disruption of the colonic mucus layer, may further facilitate the passage of MPs into the bloodstream [9]. In addition, it has been found that inhaled MPs may cross the alveolar-capillary barrier and enter the bloodstream [7,10,11].

Once in the bloodstream, MPs can circulate throughout the body, accumulate in tissues and organs, and induce toxic, immune, and inflammatory responses [7,8,12]. Their toxicity is strongly influenced by particle size, shape, chemical composition, and surface charge [13]. Circulating MPs have been associated with acute cardiovascular disease [14]; notably, patients with carotid plaques containing MPs and nanoplastics (NPs, synthetic polymer particles smaller than 1μm) exhibited a

 doi:10.20944/preprints202602.1343.v1

significantly increased risk of myocardial infarction, stroke, or death within 34 months [15]. Beyond cardiovascular effects, MPs and particularly NPs have been linked to neurological damage. By crossing the blood–brain barrier and accumulating in brain tissue, they may interact with α-synuclein fibrils and accelerate pathological spread, potentially contributing to neurodegenerative diseases such as Parkinson's disease and dementia [16–18]. MPs also disrupt gut microbiota and intestinal barrier integrity, facilitating the translocation of MPs, bacteria, and metabolites to the liver and promoting hepatic injury [19]. In addition, MPs induce renal histological and functional damage, altering urea nitrogen and creatinine levels and triggering pro-inflammatory cytokine release (IL-1β, IL-6, TNF-α) [20]. Finally, MPs can impair reproductive health by disrupting the blood–testis barrier and spermatogenesis in males, and by inducing placental dysfunction, ovarian atrophy, endometrial hyperplasia, and fibrosis in females [21].

Blood cells themselves can be directly affected by MPs. Both MPs and NPs have been shown to exert detrimental effects on red and white blood cells, primarily through mechanisms involving oxidative stress, membrane damage, and interference with cellular development. In animal studies, red blood cells exhibited reduced counts, decreased hemoglobin levels, and morphological abnormalities (e.g., poikilocytosis), suggesting anemia-like effects and impaired heme synthesis [22–24]. A study has shown that erythrocytes from C57BL/6 mice treated with MPs (6, 60, and 600 µg/day) for 15 days displayed various morphological patterns of malformed cells [25]. White blood cell counts were reduced, and DNA damage in monocytes and neutrophils, as well as altered cytokine secretion, indicated disruption of immune function [22,26]. These effects were often dose- and size-dependent, with smaller particles causing more pronounced damage.

To better understand the potential risks of MPs to animal and human blood and overall health, various in vitro studies and both acute and chronic animal models have been employed. In this study, the effects of subchronic oral exposure to polystyrene microplastics (PS-MPs) over a period of 4 weeks, followed by a 2-week recovery period without PS-MPs intake, on hematological and biochemical parameters of mice were investigated. The aim was to evaluate whether subchronic exposure to PS-MPs causes lasting changes in white and red blood cell counts, as well as in liver and kidney function biomarkers, and to assess the potential for recovery following a period without PS-MP intake.

2. Materials and Methods

2.1. Microplastics

The PS-MPs, with a diameter of 1 µm, were purchased from Magsphere Inc. (Pasadena, USA). The particles were suspended in ultrapure water at the required dose and dispersed using ultrasonic treatment (20 kHz, 30 minutes) to ensure uniform distribution.

2.2. Animals

Six-week-old male Swiss albino mice were obtained from the Experimental and Breeding Base for Laboratory Animals (Slivnitsa, Bulgaria) and acclimated for one week under standard conditions (12/12 h light/dark cycle, 25 ± 2 °C, 50 ± 5% humidity) with ad libitum access to water and standard chow. Mice were randomly assigned to control or experimental groups. Controls received drinking water, while the experimental group was administered 1 µm PS-MPs in drinking water at a dose of 0.01 mg/day for four weeks, followed by a two-week recovery period without exposure. The dose was calculated based on an average water intake of 5 mL/day/mouse. Animal health and behavior were monitored daily; body weight was recorded weekly, and food and water intake were measured twice weekly. Each week, six mice from each group were euthanized by decapitation under light anesthesia, and blood was collected in EDTA vacutainers for hematological and biochemical analyses. As no significant differences were observed among control mice over the six-week period, control data were pooled and designated as Week0. Experimental groups were labeled Week1 to Week6 according to the duration of the study.

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2.3. Hematological Analyses

The samples were analyzed for complete blood count by Mindray BC-2800VT (Mindray Bio-Medical Electronics Co., Ltd., Shenzhen, China). The analyses included: White Blood Cells (WBC, G/L); Lymphocyte Count (Lymph#, G/L); Monocyte Count (Mon#, G/L); Granulocyte Count (Gran#, G/L); Lymphocyte Percentage (Lymph%, %); Monocyte Percentage (Mon%, %); Granulocyte Percentage (Gran%, %); Red Blood Cells (RBC, T/L); Hemoglobin (HGB, g/L); Hematocrit (HCT, %); Mean Corpuscular Volume (MCV, fL); Mean Corpuscular Hemoglobin (MCH, pg); Mean Corpuscular Hemoglobin Concentration (MCHC, g/L); Red Cell Distribution Width (RDW, %); Platelets (PLT, G/L); Mean Platelet Volume (MPV, fL); Platelet Distribution Width (PDW, %); Plateletcrit (PCT, %).

2.4. Biochemical Analyses

The key biochemical indicators in plasma: Alanine Aminotransferase (ALT, U/L); Aspartate Aminotransferase (AST, U/L); AST/ALT Ratio; Urea (mmol/L); Creatinine (CRE, μmol/L); Blood Urea Nitrogen to Creatinine Ratio (BUN/CRE); Glucose (GLU, mmol/L) were analyzed by Chemistry Analyzer Celercare V5 (Tianjin MNCHIP Technologies Co., Ltd, Tianjin, China).

2.5. Statistics

The descriptive statistics and one-way ANOVA were provided by SPSS 26 (IBM, USA). Mean values were presented as Mean ± SD.

3. Results

3.1. White Blood Parameters

The comparative data of WBC parameters in experimental mice and a control group over a six-week period are presented in Table 1. The control group exhibited a mean WBC count of 7.2 ± 1.14 G/L without a significant change in the first week. From week 2 to week 6, WBC levels significantly increased in the experimental groups compared to the Control. These results suggested a notable perturbation of the white blood cell count following MPs exposure, particularly pronounced after the first week. Similar dynamics were maintained for the mean counts of lymphocytes and granulocytes: a significant increase was observed in the experimental groups from week two to week six compared to the control group. These dynamics indicated a strong immune response shortly after exposure, which persists at a higher level throughout the experiment. The monocyte count remained unchanged during the observation period.

The percentages of lymphocytes and granulocytes remained stable throughout the experimental weeks, indicating that the proportion of lymphocytes among white blood cells was largely unaffected by MPs exposure, despite fluctuations in absolute counts (Table 1). The percentage of monocytes in the experimental groups was significantly lower than in the control group (Table 1). This pattern mirrored the absolute monocyte count, indicating a consistent drop in monocyte proportion in response to exposure.

Table 1. White blood parameters (Mean ± SD) in control and experimental groups.

Parameter	Control	Week1	Week2	Week3	Week4	Week5	Week6
WBC (G/L)	7.2 ± 1.14 ^{2***,3**,4***,5***,6***}	6.2 ± 1.95 ^{2***,3*,4***,5***,6***}	18.5 ± 4.61 ^{Co***,1***}	12.7 ± 3.55 ^{Co**,1*}	16.7 ± 2.69 ^{Co***,1***}	17.7 ± 2.08 ^{Co***,1***}	14.9 ± 5.22 ^{Co***,1***}
Lymph#(G/L)	5.1 ± 1.20 ^{2***,3*,4***,5**,6*}	4.6 ± 1.81 ^{2***,3*,4**,5**}	10.9 ± 2.58 ^{Co***,1***}	8.4 ± 2.40 ^{Co*,1*}	9.8 ± 2.58 ^{Co***,1**}	9.8 ± 1.46 ^{Co**,1**}	8.5 ± 1.84 ^{Co*}
Mono# (G/L)	1.2 ± 0.60	0.7 ± 0.11	0.8 ± 0.34	0.7 ± 0.18	1.1 ± 0.63	0.7 ± 0.18	1.0 ± 0.32
Gran# (G/L)	2.2 ± 0.69 ^{2***,4***,5**,6**}	1.4 ± 0.26 ^{2***,3*,4***,5**,6**}	5.8 ± 2.35 ^{Co***,1***}	4.0 ± 0.48 ^{1*}	5.6 ± 1.12 ^{Co***,1***}	5.2 ± 1.07 ^{Co**,1**}	4.8 ± 2.61 ^{Co**,1**}
Lymph% (%)	69.7 ± 9.55	73.1 ± 7.41	60.1 ± 9.92	67.2 ± 12.89	58.2 ± 10.07	56.5 ± 13.17	58.8 ± 7.39

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Mono% (%)	17.0 ± 9.04 1**,2*,3*,4*,5*	3.7 ± 0.69 Co**	4.3 ± 1.71 Co*	5.7 ± 2.92 Co*	6.8 ± 3.98 Co*	3.9 ± 0.83 Co*	6.7 ± 2.00
Gran% (%)	30.3 ± 9.00	24.4 ± 9.76	31.1 ± 10.86	34.0 ± 11.68	33.9 ± 6.47	29.8 ± 6.49	31.4 ± 6.15

* The numbers in every second row in the table indicate a statistically significant difference compared to the corresponding group (Co – Control, 1 – Week1, 2 – Week2, 3 – Week3, 4 – Week4, 5 – Week5, 6 – Week6); Differences were considered significant at *P < 0.05, **P < 0.01, and ***P < 0.001..

3.2. Red Blood Parameters

A comprehensive overview of RBC and platelet-related hematological parameters in the experimental groups of mice exposed to MPs over a four-week period, followed by a two-week recovery, compared to the control group, is summarized in Table 2.

The control group showed a mean RBC count of 9.6 ± 1.20 T/L. In the experimental groups, RBC counts remained unchanged compared to the controls. Only in Week6 was a significant increase observed compared to Week1. The mean hemoglobin level was 144.8 ± 21.03 g/L in controls. The highest value of 174.3 ± 3.50 g/L was observed in Week6; however, this increase was not statistically significant. The control group mean hematocrit was 46.4 ± 6.19%. The value reached a statistically insignificant rise of 52.2 ± 1.65% in Week6. The mean values of the other tested red blood parameters (MCV, MCH, MCHC, and RDW) did not show remarkable changes. Platelet counts in the control group were 470.1 ± 121.87 G/L, and significantly increased in Week6 (725.8 ± 307.96 G/L). The average values for the additional platelet parameters (MPV, PDW, and PCT) remained unchanged throughout the study period.

Table 2. Red blood parameters (Mean ± SD) in control and experimental groups.

Parameter	Control	Week1	Week2	Week3	Week4	Week5	Week6
RBC (T/L)	9.6 ± 1.20	8.7 ± 1.24 6*	9.4 ± 0.73	9.3 ± 0.96	9.5 ± 0.89	9.6 ± 0.92	11.3 ± 0.52
HGB (g/L)	144.8 ± 21.03	138.2 ± 27.11	153.8 ± 16.82	141.2 ± 22.69	160.0 ± 21.06	154.3 ± 7.89	174.3 ± 3.50
HCT (%)	46.4 ± 6.19	41.9 ± 16.47	47.7 ± 5.32	44.0 ± 6.31	48.7 ± 6.16	47.6 ± 1.40	52.2 ± 1.65
MCV (fL)	47.5 ± 3.74	49.3 ± 3.74	50.6 ± 3.03	47.2 ± 2.54	51.3 ± 1.97	49.9 ± 3.50	47.4 ± 0.97
MCH (pg)	15.3 ± 1.36	15.8 ± 1.06	16.3 ± 0.86	15.1 ± 0.98	16.8 ± 0.73	16.1 ± 0.81	15.7 ± 0.22
MCHC (g/L)	323.8 ± 11.70	321.0 ± 9.22	321.8 ± 2.50	319.8 ± 8.41	327.8 ± 3.49	323.5 ± 8.19	326.0 ± 4.24
RDW (%)	16.4 ± 2.86	13.7 ± 2.61	16.5 ± 2.06	15.0 ± 1.88	14.9 ± 1.52	15.0 ± 1.29	13.7 ± 0.57
PLT (G/L)	470.1 ± 121.87 6*	439.4 ± 115.11	295.8 ± 78.81 6**	271.4 ± 85.94 6***	358.6 ± 85.55 6**	324.8 ± 44.51 6**	725.8 ± 307.96 Co*,2*,3***,4**,5**
MPV (fL)	5.6 ± 0.62	5.5 ± 0.32	5.5 ± 0.36	5.4 ± 0.29	5.7 ± 0.28	5.7 ± 0.49	5.9 ± 0.38
PDW (%)	16.5 ± 0.65	16.3 ± 0.58	16.7 ± 0.31	16.4 ± 0.29	16.6 ± 0.22	16.8 ± 0.46	16.9 ± 0.33
PCT (%)	0.4 ± 0.16	0.3 ± 0.12	0.2 ± 0.04	0.2 ± 0.11	0.2 ± 0.10	0.2 ± 0.08	0.4 ± 0.20

* The numbers in every second row in the table indicate a statistically significant difference compared to the corresponding group (Co – Control, 1 – Week1, 2 – Week2, 3 – Week3, 4 – Week4, 5 – Week5, 6 – Week6); Differences were considered significant at *P < 0.05, **P < 0.01, and ***P < 0.001.

 doi:10.20944/preprints202602.1343.v1

3.3. Blood Biochemical Parameters

A comparison was made of several biochemical parameters measured in the blood of experimental mice exposed to MPs over a four-week period, followed by a 2-week recovery, and with the control group (Table 3).

The control group showed a mean ALT level of 68.1 ± 6.13 U/L. In the experimental groups, ALT increased significantly in 1, 2, 3, and 6 weeks, reaching 117.5 ± 20.62 U/L. The control mice had an AST level of 126.2 ± 25.64 U/L. In the experimental groups, AST increased significantly in all weeks, with a maximum in Week1 (458.2 ± 90.93 U/L). The AST/ALT ratio exhibited the same dynamics as AST, but with significantly elevated values in weeks 1, 4, and 5.

Control mice had urea levels of 10.0 ± 1.88 mmol/L. Mice in the experimental groups showed a significant increase in urea in Week2 and Week6.

The control group's CRE was 43.5 ± 15.61 μmol/L and remained low in Week1. After that, in Week3, Week4, and Week5, a significant increase was observed. In Week6, the CRE decreased insignificantly to 28.8 ± 2.06 μmol/L. The BUN/CRE ratio was 63.2 ± 25.96 in controls. In the experimental groups, this ratio increased insignificantly to 101.9 ± 31.43 in Week1 and decreased during weeks 2 to 5. A significant increase to 168.4 ± 29.68 was observed in Week6.

Control mice had glucose levels of 7.3 ± 1.57 mmol/L. Experimental groups showed a significant rise in Week5 (12.3 ± 2.58 mmol/L) and a subsequent decrease in Week6 (6.0 ± 1.86 mmol/L).

Table 3. Blood biochemical parameters (Mean ± SD) in control and experimental groups.

Parameter	Control	Week1	Week2	Week3	Week4	Week5	Week6
ALT (U/L)	68.1 ± 6.13 1*,2*,3**,6**	106.0 ± 40.4 Co*	105.0 ± 21.5 Co*	115.0 ± 31.5 Co***	84.2 ± 11.1	87.8 ± 12.1	117.5 ± 20.6 Co**
AST (U/L)	126.2 ± 25 1***,2***,3***,4***,5***,6***	458.2 ± 90 Co***,2*,3*,4*	332.5 ± 30 Co***,1*	339.0 ± 59 Co***,1*	351.0 ± 75 Co***,1**	369.3 ± 48 Co***	360.3 ± 6 Co***
AST/ALT	1.9 ± 0.39 1***,4***,5***	4.8 ± 2.13 Co***,3*	3.3 ± 0.85	3.0 ± 0.44 1*	4.2 ± 0.68 Co***	4.2 ± 0.28 Co***	3.1 ± 0.59
Urea (mmol/L)	10.0 ± 1.88 2***,6***	13.0 ± 3.2 2**,6**	19.1 ± 2.5 Co***,1**,3**,4***,5***	12.5 ± 1.6 2**	10.2 ± 2.2 2***	10.4 ± 0.67 2***	19.6 ± 3.5 Co***,1**
CRE (μmol/L)	43.5 ± 15.61	32.4 ± 5.7 2*	66.0 ± 19.8 1*,6*	52.0 ± 3.3	42.6 ± 25.4	62.0 ± 8.2	28.8 ± 2.06 2*
BUN/CRE	63.2 ± 25.96 6***	101.9 ± 31.4 5*,6**	75.6 ± 21.1 6***	59.5 ± 7.9 6***	70.7 ± 29.5 6***	42.4 ± 9.1 1*,6***	168.4 ± 29.6 Co***,1**,2***,3***,4***,5***
GLU (mmol/L)	7.3 ± 1.57 5***	5.2 ± 0.68 5***	7.6 ± 1.06 5**	7.6 ± 0.86 5**	5.5 ± 0.88 5***	12.3 ± 2.5 Co***,1***,2**,3**,4***6***	6.0 ± 1.8 5***

* The numbers in every second row in the table indicate a statistically significant difference compared to the corresponding group (Co – Control, 1 – Week1, 2 – Week2, 3 – Week3, 4 – Week4, 5 – Week5, 6 – Week6); Differences were considered significant at *P < 0.05, **P < 0.01, and ***P < 0.001.

4. Discussion

Blood is a preferred matrix for health assessment because it can be obtained with minimal invasiveness and provides a comprehensive reflection of the body's overall physiological state [27]. Circulating through all organs, blood enables the evaluation of numerous biomarkers associated with organ function, disease processes, and metabolic activity. Hematological and biochemical parameters serve as critical indicators of health status. They are routinely measured using standardized, reliable assays that offer rapid and accurate insights into physiological alterations, making them indispensable for both diagnosis and clinical monitoring.

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Present knowledge indicates that MPs can circulate in the blood and may enter various organs [28]. However, there is little data on their specific effects on blood parameters in mammals. The present study aimed to determine the effects of 1 μm PS-MPs on main hematological and biochemical parameters in experimental mice after a four-week exposure, followed by two weeks without plastic administration. The results obtained clearly demonstrate that exposure to 1 μm PS-MPs leads to marked changes in several blood cell fractions and indicators of organ functions.

In this experiment, significant increases were observed in total white blood cell and lymphocyte counts, as well as in granulocyte numbers, compared with controls (see Table 1). These trends indicated the presence of a dynamic and potentially stress-related immune response to PS-MPs exposure over time. Our data aligns with a study indicating that white blood cells and immune cells that phagocytose MPs can provoke inflammation [23]. Similarly, it has been found that both commercial and environmental MPs and NPs can trigger strong inflammatory responses in human peripheral blood mononuclear cells and whole blood cell cultures. Applied in a concentration of 1 mg/mL, they markedly increased IL-1β and IL-6 secretion in a time-dependent manner [29]. A murine model fed polyethylene particles exhibited increased inflammation in the small intestine, accompanied by alterations in microbiota and elevated systemic pro-inflammatory markers [23,30]. Increased WBC and neutrophils were detected after exposure of mice to 600 μg/day for 15 days [25]. In another study, however, a decrease in white blood cells and their subtypes, i.e., lymphocytes and neutrophils, was observed in rats orally administered MPs in high concentrations (5% and 10%) [24]. A reduction in lymphocyte and monocyte counts was observed after mice were exposed to 60 and 600 μg/day for 15 days [25]. This suggests that variations in white blood cells are strongly influenced by the exposure dose and duration, as well as by the size and morphology of the MPs.

Regarding red blood cell parameters, in the present experimental study, exposure to PS-MPs in mice led to modest fluctuations. This observation appears reasonable, as red blood cells are not involved in the immune response, unlike WBC, which are immunologically active, making them more responsive to environmental stressors, including MPs. Similar results were obtained without significant changes in RBC count, hemoglobin, hematocrit, MCV, MCH, and MCHC after administering 1%, 5%, and 10% oral MPs in rats [24]. The most notable change among red blood parameters was the significant increase in PLT values in Week6, whereas most other indices remained relatively stable (see Table 2). Similar to the results obtained herein, an increased PLT count was observed in mice treated with 0.5 mg/day 5 μm PS-MPs by oral gavage for 28 days [26] and in rats with 5% and 10% oral administration of MPs for 28 days [24]. It has also been found that activated platelets may release pro-inflammatory mediators that contribute to vascular inflammation and immune dysregulation following MPs and NPs exposure. However, in a study, the exposure of mice to 60 and 600 μg/ml MPs for 15 days led to considerably lower RBC count, hemoglobin, and hematocrit levels [25].

The results obtained in this study demonstrated changes over time in several measured blood biochemical parameters in the mice exposed to PS-MPs. Notable elevations were observed in liver enzymes (ALT, AST), suggesting a potential disturbance in liver function (see Table 3). Indeed, it was found that MPs' abundance was highest in the liver, small intestine, and kidneys; hence, these organs are likely to be the most affected by MPs' toxicity [31]. The increased ALT and AST blood levels are clear signs of hepatocellular damage upon PS-MPs exposure [32,33]. The underlying mechanism of this damage appears to be driven by oxidative stress and inflammation [33,34]. In vitro studies using liver organoids generated from human pluripotent stem cells as an alternative model to the human liver [35] and human hepatocellular (HepG2) liver cells [34] have confirmed that PS-MPs induce hepatotoxicity and disrupt liver metabolism.

Creatinine is widely used as a biomarker for renal impairment and as an indicator of glomerular filtration rate [36]. The results obtained in this study showed a maximal rise in urea and CRE levels in Week2 of the exposure period. Scientific evidence shows variations in blood biomarkers of kidney damage induced by MPs. Studies using kidney organoids have demonstrated that MPs induce the fusion of podocyte processes, thereby compromising the glomerular filtration barrier [37–39]. The

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exposure of human embryonic kidney (HEK 293) cells to 1 μm PS-MPs for 72 h showed significant morphological changes, increased levels of reactive oxygen species, and lower gene expression levels of the glycolytic and antioxidant enzymes [34]. An increase in CRE was also found after 15 days of treatment with high doses (60 and 600 μg/ml) of MPs, but not at a dose of 6 μg/ml [25]. MPs cause histological damage to the kidneys by affecting serum urea nitrogen and creatinine levels, and promoting the release of inflammatory mediators such as IL-1β, IL-6, and TNF-α [20]. Prolonged exposure to MPs has been linked to elevated levels of blood urea nitrogen and creatinine, indicating impaired renal function and suggesting that the kidneys, as primary organs of waste filtration, represent critical targets for MPs accumulation and toxicity [40]. Mice exposed to 0.1 and 1 mg/L PS-MPs in drinking water for eight weeks had decreased levels of blood urea nitrogen, while serum CRE and uric acid concentrations remained unaffected.

The experimental results obtained herein revealed fluctuations in blood glucose levels, characterized by a marked increase during Week5, followed by normalization in Week6. This effect may, at least in part, result from pancreatic damage following prolonged exposure to PS-MPs. Previous studies have shown that oral exposure to polyethylene terephthalate MPs can trigger pancreatic immune responses and oxidative stress, thereby disrupting glucose metabolism [41]. Alternatively, the observed hyperglycemia may be associated with impaired hepatic metabolism, resulting in elevated blood glucose levels [42].

Our data did not reveal significant improvements in hematological or biochemical parameters after cessation of MP exposure, which is likely due to its accumulation in tissues and organs and its slow clearance from the body. Consistent with this, Deng et al. [43] reported that PS-MPs with diameters of 5 μm and 20 μm were still detectable in the intestines, liver, and kidneys of mice one week after termination of a 28-day exposure period. The concentration of MPs appears to play a critical role in recovery outcomes. At lower doses, MPs accumulation and the associated hemato-biochemical alterations observed after 28 days of exposure showed improvement following a 15-day recovery period compared with controls, whereas animals exposed to higher doses exhibited persistent adverse effects of MPs exposure [25].

5. Conclusions

This study demonstrates that oral exposure to PS-MPs induces significant physiological disturbances in mice. Continuous intake of 0.01 mg/day for four weeks altered hematological and biochemical parameters, with only limited recovery after exposure cessation. Elevated leukocyte and platelet counts indicated persistent inflammation, while increased ALT, AST, urea, and BUN/CRE ratios suggested hepatic and renal impairment. A transient rise in blood glucose further pointed to possible pancreatic dysfunction.

The lack of substantial recovery likely reflects tissue accumulation and slow clearance of MPs. Overall, these findings highlight the systemic effects of MPs on multiple organs and their capacity to disrupt physiological homeostasis. Further studies are needed to elucidate MP toxicokinetics, underlying mechanisms, and relevance to human health, underscoring the importance of reducing environmental plastic pollution and MP exposure.

Author Contributions: Conceptualization, L.P. and A.A.; methodology, L.P.; formal analysis, E.T., A.G., M.A., G.Pr, G.P. and K.D.; investigation, E.T., A.G., M.A., G.Pr, G.P. and K.D.; resources, M.A.; data curation, K.D. and L.P.; writing—original draft preparation, A.A. and L.P.; writing—review and editing, A.A. and L.P.; visualization, L.P.; supervision, A.A. and L.P.; project administration, A.A.; funding acquisition, A.A. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by Grant № KP-06-H81/2, National Science Fund, Sofia, Bulgaria.

Institutional Review Board Statement: The animal study protocol was approved by the Animal Ethics Committee of the Bulgarian Food Safety Agency (Approval No. 424/24.02.2025) and was conducted in strict accordance with internationally accepted standards and regulations.

 doi:10.20944/preprints202602.1343.v1

Informed Consent Statement: Not applicable.

Data Availability Statement: The raw data of presented in the study results are openly available in Zenodo research repository at https://zenodo.org/records/17746961.

Conflicts of Interest: The authors declare no conflicts of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

Abbreviations

The following abbreviations are used in this manuscript:

ALT	Alanine Aminotransferase
AST	Aspartate Aminotransferase
BUN/CRE	Blood Urea Nitrogen to Creatinine Ratio
CRE	Creatinine
GLU	Glucose
Gran#	Granulocyte Count
Gran%	Granulocyte Percentage
HCT	Hematocrit
HGB	Hemoglobin
IL	interleukin
Lymph#	Lymphocyte Count
Lymph%	Lymphocyte Percentage
Mono#	Monocyte Count
Mono%	Monocyte Percentage
MCH	Mean Corpuscular Hemoglobin
MCHC	Mean Corpuscular Hemoglobin Concentration
MCV	Mean Corpuscular Volume
MPs	microplastics
MPV	Mean Platelet Volume
NPs	nanoplastics
PCT	Plateletcrit
PDW	Platelet Distribution
PLT	Platelets
PS-MPs	polystyrene microplastics
RBC	Red Blood Cells
RDW	Red Cell Distribution Width
TNF	Tumor Necrosis Factor
WBC	White Blood Cells

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