RECREATION AND WATER PRODUCTION FUNCTIONS: A CONTRADICTION?

Serengi Yusuf, Özhan Süleyman
Istanbul University Faculty of Forestry - Bahceköy/Istanbul

Abstract

Recreational use represents one of the major functions of the forest areas in Turkey. Owing to the fast and inappropriate urbanization trend and increasing population, the forest service is going to face with a huge increase in the public demand in the major cities, in the next decades. On the other hand, it is an ongoing argument whether recreational use goes with the water production functions of the forests. Some specific management approaches and methods can reconcile these uses. In this paper after a brief explanation of the main points of the issue and our approach towards handling the problem, the hydrologic consequences of a recreation area located in water producing watersheds is evaluated. A two-year water quality-monitoring program was performed in the recreation area together with a soil study mainly focused on the changes in hydro physical properties. Although, field observations indicated a considerable level of erosion and soil compaction, water quality values did not point a significant problem. The situation was different when soil hydro physical properties were evaluated. 10 sampling transects were determined perpendicular to the creek and double core soil sampling was performed at 4 points (1 and 3 metres away, on both banks of the creek) on each, together with the soil samples taken from the fairly trampled, heavily trampled and forested areas. The saturated hydraulic conductivity values (SHC) decreased significantly in intensively trampled areas. The average SHC value of the intensively used area was determined as 6.45 cm/hr, while it was measured quite high (26.17 cm/hr) at the fairly trampled part of the recreation area. Similar results were obtained for bulk density. Fine textured soil particles and organic matter percentage was low on the stream banks. It was apparent that some hydro physical soil properties were negatively affected from recreational activities. However, because the soils were mostly coarse textured and the area was flat, the trampling effects were lower than expected. In general the recreational activities in the area found to be harmless and were not in contradiction with the water production function.

Key words: Recreation, water production, water quality, monitoring, soil hydraulic properties

INTRODUCTION

Istanbul city faced water supply problems in the last couple of decades. Although it is a relatively humid region compared to the other parts of the country, a few subsequent
dry summer seasons caused water shortage in 1990s' (Uroğlu et al., 2001). The government and the municipality implemented very expensive pipeline projects in order to solve the problem. All water resources in a circle of 300 kilometers were considered as a potential water supply area (Yapıcı, Uroğlu, 2001). However, many reservoirs became polluted by new settlements in the watersheds. The human settlements also caused the recreation areas to diminish and become over utilized.

Recreation and other green areas are important components of life in cities. Hence, they should be managed in a way that will not contradict with the other purposes of forestry. When evaluating a recreation area for its influences, the main principle should be considering it as a part of its watershed system. In this approach the main point (also output) have to be the continuity principle (Fig. 1). The source of impact (input) is the visitors and their activities in the recreation area. For the continuity of the system, the level of impact should be determined and controlled. In this hypothetical subsystem the one-way impact flux from recreation area to the reservoir should go not only with the water quality criteria but also the ecological health of the system particularly in the hydrological point of view. In other words, considering only the water quality standards might not be a sufficient effort to achieve the continuity in the long run.

In this paper, several water quality parameters were monitored for a 2 years period and together with the results of soil study an evaluation have been made on whether recreational activities are effective on the water production function of the forest ecosystems or not. The approach in this study to evaluate the effects of the recreation area was to find out the answers of the following questions:

- Are there negative effects on the soils of the recreation area caused by trampling? Is there any deterioration indicator on the water quality of the stream passing through the recreation area and any proof that is caused by any human activity?

If there is deterioration on the stream water quality, is it also affecting the water quality of the Buyukbent Reservoir located below the recreation area?

**METHODS**

**Study Area**

The study was conducted on two creeks that connect after draining similar sized small watersheds. The watersheds named as A and B was covered with deciduous forest ecosystems. Watershed A had an area of 150.3 ha with an average elevation of 145.3 metres while B had an area and elevation of 134.5 ha and 122.3 metres, respectively. The mean slopes of the watersheds were quite similar: 21.6% for watershed A and 18.9% for watershed B.

The Nesetuyu recreation area (1.5 ha) which serves since 1956 (Pehlivanoglu, 1987) is located in the downstream area (0-5% slope) where two creeks met. The coordinates of the sampling points were 41° 11' 15" North and 28° 58' 04" East with an elevation varying from 81 to 85 m (Fig. 2).

The region is described as 'humid, oceanic and some water shortage in summer' according to Thorndhaite method and classified as B_B'4,5'6'7' (Serengil, Ozhlan, 2001). The nearest meteorological station (5 km) receives an average of 1050 mm of rainfall annually. Two different parent soil materials were determined in the region including carboniferous (clay greywacke-schist) and neogene formations (upper plioen) (Ozhlan, 1977). Study catchments are located on neogen material that generated deep, acidic, coarse textured and gravelled soils. The region was included into the Castanetum-Fagetum vegetation zone (Ozhlan, 1977). Vegetation belts according to elevation are: *Quercus frainetto, Quercus cerris* and *Castanea (<100 m)*; *Tilia-Castanea (100-180 m)*; and *Quercus petrea, Tilia, Castanea* (180-240 m). Many other tree and shrub species were also recorded in the region either natural or planted.
Sampling and Analyses

The monitoring period was 2 water years (1999-00 and 2000-01). Five sampling points (SP) were established on the creeks (Fig. 3) and sampling was performed manually for 15-day intervals.

The total number of stream water samples was 51 on each sampling point. The analysed water quality parameters were pH, turbidity, electrical conductance (EC), dissolved oxygen concentration (DO) and saturation, water temperature, Mg²⁺, K⁺, Na⁺, NO₃⁻, NH₄⁺, PO₄³⁻, and Cl⁻.

Soil sampling was done both in the intensive recreation areas and in the non-recreational forested areas of the watersheds and also stream banks. Soil sampling was performed on transects perpendicular to stream channel. In addition, soil samples taken from stream banks were compared with the ones taken in and outside the recreation area (forested). The recreation area is separated into 3 zones. The heavily trampled center is called intensive recreation area while another less trampled belt (fair recreation area) existed around it (Fig. 3). The remaining part of the watersheds was all forested. The criteria to identify these zones were the abundance of picnic tables and number of visitors.

The analyses performed on the soil samples were EC, pH, saturated hydraulic conductivity (SHC), bulk density, organic matter percentage (OM) and texture. Topsoil samples (0-10 cm) were taken from 73 points in the watersheds with intensive systematic grid sampling pattern and from 40 points on the stream bank. Stream bank soil sampling points were taken on 10 cross sections along the creek. 4 Sampling points were taken on each transect named according to their side and distance to the creek (a1, a3, b1, b3). The first and the last 2 transects were in the fair recreation zone while the center ones were in the heavy recreation zone.

By implementing a transect survey along the channel we aimed to observe the changes in the soil properties passing through the center of the recreation area and at the same time to identify the trampling effects on the soils of the stream bank.

![Fig. 3. Schematic representation of the soil and water sampling points](image)

Laboratory analytical methods

Nitrate, K⁺, and Na⁺ were measured using Orion ISE multimeter (ion selective electrode technique). PO₄³⁻, Mg²⁺ and NH₄⁺ were analyzed with Dr Lange digital photometer (Ewing, 1975). Chloride with titrimetric methods (APHA-AWWA-WPCF, 1975) and pH, DO and EC with WTW Multilin pH metre. OM percentage of the soil samples was determined with Walkley-Black method (Irmak, 1956). SHC (saturated hydraulic conductivity) according to Darcy Law (Van Ielenstra et al, 1997) with procedure in (Ozuyucu, 1976) and texture with hydrometer method (Irmak, 1956).

RESULTS

Dissolved Oxygen and Water Quality Status of the Reservoir

Among the water quality parameters, DO is an indicator variable for the general health of the aquatic ecosystems. The principle effect is on the fish preservation, including survival and reproduction (Thoman, Mueller, 1987). Many researches have been conducted relating specific levels of DO to fish behavior and a complete summary is given in USEPA (1987). Thomann, Mueller (1987) explained the relationship between DO and responses such as survival, development, growth and swimming performance of chinook and coho salmonhead trout, and largemouth bass. The results indicated that juveniles survived for prolonged periods of time at dissolved oxygen concentrations as low as 2 mg/L and less, except at relatively high temperatures. However, other conclusions included the results that juvenile largemouth bass experienced some reduction in maximum swimming speeds when DO was reduced to below 5 or 6 mg/L at 25°C. In USEPA criteria 3 mg/L is accepted as acute mortality limit while problems begin under 5-6 mg/L for both coldwater and warm water fisheries. The measured DO values distributed between 2.68 mg/L and 8.49 mg/L (mean = 5.65 mg/L, median = 5.61 mg/L) (Fig. 4). The DO concentration had a seasonal variation increasing with January and start decreasing in the end of May inversely proportional with water temperature. The annual mean water temperature was 11.75 °C changing between 2.0 °C and 29.7 °C (for the 2 years of monitoring period).

As seen from Fig. 4, 50% of the measured DO values (51 measurements in 2 years) distributed between 4.8 mg/L and 6.4 mg/L that indicates a fairly favorable condition for the fish population of the reservoir. The 2-year mean values of the measured water quality parameters are given in Table 1.

The measured water quality parameters were compared the data given by Biswas (1996) based on the quality criteria of Russia and Canada for the aquatic life and recreational purposes. It was even in good quality and suitable for a drinking water supply according to WHO, USEPA and Canada regulations (Ryding, 1989).

Spatial Change in Water Quality Parameters

The mean concentrations of the measured water quality parameters at the sampling points were given in Table 2.
Fig. 4. Box plot distribution of DO values of the Buyukbent Reservoir

Table 1
Mean water quality values of Buyukbent Reservoir

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Reservoir Water</th>
<th>Parameter</th>
<th>Unit</th>
<th>Reservoir Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>NU</td>
<td>6.89</td>
<td>Na</td>
<td>mg/L</td>
<td>9.74</td>
</tr>
<tr>
<td>EC</td>
<td>μS/cm</td>
<td>201.6</td>
<td>Mg</td>
<td>mg/L</td>
<td>4.35</td>
</tr>
<tr>
<td>Temperature</td>
<td>°C</td>
<td>11.75</td>
<td>Al</td>
<td>mg/L</td>
<td>0.01</td>
</tr>
<tr>
<td>PO₄</td>
<td>mg/L</td>
<td>3.17</td>
<td>Fe</td>
<td>mg/L</td>
<td>0.66</td>
</tr>
<tr>
<td>SO₄</td>
<td>mg/L</td>
<td>9.0</td>
<td>K</td>
<td>mg/L</td>
<td>2.53</td>
</tr>
<tr>
<td>Cl</td>
<td>mg/L</td>
<td>4.74</td>
<td>Turbidity</td>
<td>mg/L</td>
<td>31.15</td>
</tr>
<tr>
<td>NO₃</td>
<td>mg/L</td>
<td>2.94</td>
<td>Color</td>
<td>unit</td>
<td>20</td>
</tr>
<tr>
<td>DO</td>
<td>mg/L</td>
<td>5.65</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2
The mean concentrations of the measured water quality parameters at the sampling points

<table>
<thead>
<tr>
<th>IR</th>
<th>pH</th>
<th>T</th>
<th>DO</th>
<th>Na</th>
<th>Mg</th>
<th>K</th>
<th>NH₄</th>
<th>SO₄</th>
<th>NO₃</th>
<th>PO₄</th>
<th>Cl</th>
<th>Turbidity</th>
<th>SiO₂</th>
<th>F</th>
<th>CO₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP1</td>
<td>193.73</td>
<td>6.85</td>
<td>11.16</td>
<td>6.68</td>
<td>10.65</td>
<td>3.13</td>
<td>2.98</td>
<td>0.23</td>
<td>7.00</td>
<td>2.89</td>
<td>3.03</td>
<td>5.34</td>
<td>31.85</td>
<td>20.0</td>
<td></td>
</tr>
<tr>
<td>SP2</td>
<td>252.38</td>
<td>6.86</td>
<td>10.64</td>
<td>5.94</td>
<td>10.84</td>
<td>3.71</td>
<td>2.64</td>
<td>0.22</td>
<td>7.47</td>
<td>2.90</td>
<td>3.43</td>
<td>6.10</td>
<td>44.62</td>
<td>20.0</td>
<td></td>
</tr>
<tr>
<td>SP3</td>
<td>218.48</td>
<td>6.97</td>
<td>11.01</td>
<td>6.05</td>
<td>10.30</td>
<td>4.02</td>
<td>2.55</td>
<td>0.24</td>
<td>9.33</td>
<td>2.41</td>
<td>3.21</td>
<td>5.28</td>
<td>42.23</td>
<td>20.0</td>
<td></td>
</tr>
<tr>
<td>SP4</td>
<td>230.39</td>
<td>6.00</td>
<td>10.86</td>
<td>6.13</td>
<td>10.79</td>
<td>3.56</td>
<td>2.55</td>
<td>0.29</td>
<td>8.90</td>
<td>2.66</td>
<td>3.23</td>
<td>5.42</td>
<td>42.83</td>
<td>20.0</td>
<td></td>
</tr>
<tr>
<td>SP5</td>
<td>201.60</td>
<td>6.89</td>
<td>11.75</td>
<td>5.65</td>
<td>9.74</td>
<td>4.35</td>
<td>2.55</td>
<td>0.32</td>
<td>9.00</td>
<td>2.04</td>
<td>3.17</td>
<td>4.74</td>
<td>31.85</td>
<td>20.0</td>
<td></td>
</tr>
</tbody>
</table>

Notes: a. In the same group in mean comparison with Tukey t test in %5 level of significance.

SP1 and SP2 were located on different creeks draining similar sized forested watersheds as explained above. Thus, the ionic composition of their water was quite close. On the other hand, SP3 was located at the conjunction point of SP1 and SP2 and was a mixture of two creeks. The mean water quality parameters of the 3rd, 4th and 5th SPs were compared using Tukey test and a statistically significant difference was found for turbidity and DO.

Effects on Soil Properties

The soil properties taken from intensive and fair recreation areas were compared with the ones taken from forested upper watershed area and stream banks (Table 3).

Fair recreation and forest soils had saturated hydraulic conductance values very close to each other while soils of fair recreation bank had the highest mean SHC value. For the bulk density all sample groups had statistically same mean value. This was also true for sand fraction but forest areas had less clay content. Particularly stream banks had less clay content. On the other hand IR banks had the highest pH followed with FR banks. The electrical conductance value of the banks were also higher but had the least organic matter content.

CONCLUSIONS

Recreational activities under uncontrolled management and over utilization conditions are expected to cause effects on the major components of forest ecosystems including soil, water and biological elements. However the dimension of these influences depends on many factors like the type of ecosystem and recreational activities, climate, season, topography etc. In picnic type of recreation, accumulating around certain places of a recreation area might cause unwanted results. Picnic, trekking and running are the preferred activities in Nesetsuyu recreation area. Stream banks are also susceptible parts of the watershed fluvial systems towards soil erosion and degradation.

In this paper, the effects of the recreational activities (mostly trampling effects) have been evaluated by implementing a soil and water quality monitoring study.

Table 3. The comparison of some soil properties

<table>
<thead>
<tr>
<th>SHC</th>
<th>Bulk density</th>
<th>Clay fraction</th>
<th>Sand fraction</th>
<th>pH</th>
<th>Electrical conductance</th>
<th>Organic matter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>cm/hr</td>
<td>g/cm³</td>
<td>%</td>
<td>%</td>
<td>µS/cm</td>
<td>%</td>
</tr>
<tr>
<td>Bank IR</td>
<td>15.00</td>
<td>1.28</td>
<td>10.92</td>
<td>77.66</td>
<td>6.34</td>
<td>111.25</td>
</tr>
<tr>
<td>Bank FR</td>
<td>61.17</td>
<td>1.18</td>
<td>12.24</td>
<td>73.58</td>
<td>6.05</td>
<td>110.50</td>
</tr>
<tr>
<td>IR</td>
<td>6.45</td>
<td>1.29</td>
<td>13.53</td>
<td>75.15</td>
<td>5.90</td>
<td>80.25</td>
</tr>
<tr>
<td>PR</td>
<td>26.17  a</td>
<td>1.18</td>
<td>12.61</td>
<td>72.19</td>
<td>5.92</td>
<td>94.38</td>
</tr>
<tr>
<td>Forested</td>
<td>26.90  a</td>
<td>1.12</td>
<td>16.00</td>
<td>73.50</td>
<td>5.45</td>
<td>96.37</td>
</tr>
</tbody>
</table>

Note: IR: Intensive recreation, PR: Fair recreation, a: In the same group in mean comparison with Tukey t test in %5 level of significance.
The water quality data of the Buyukbent Reservoir that is receiving the water coming from the Nesetsuyu Recreation area showed that the dissolved oxygen concentration was not very favorable for a fish habitat but all other parameters were quite good for a drinking water supply.

When the variations of the water quality parameters among the sampling points were compared (3, 4 and 5th SPs), it was found that there was a statistical difference just for the DO and turbidity which can not be considered as an effect of recreational activities as the Reservoir (5th SP) water is already expected to have less DO and turbidity. On the other hand the effects on the soil properties were clear and variable according to the intensity of recreation. The effects were also different for the soils of the stream banks. SNC value of the stream bank of fair recreation area was higher than forest cover. The compaction caused by trampling was reflected in the intensive recreation area by low SNC and high bulk density.

Consequently, it should be stated that the effects of the recreational activities in the Nesetsuyu Picnic area were lower than expected and the degradation of the soils were not affecting the water quality of the stream and the reservoir. The favorable soil, climate and vegetation conditions were naturally effective on this result. Hence, the findings of this study are true for the own site conditions. Even to extend the findings for Belgrade Forest region additional work should be done. However, it shows that in good ecological conditions watershed system and process could overcome or absorb the recreational human impacts mentioned above.

Acknowledgements: This work was supported by the Research Fund of the Istanbul University. Project number 1272/050599.

REFERENCES


Serengil Yusuf
Istanbul University Faculty of Forestry, 
Dept. of Watershed Management
34473, Bahçeköy/Istanbul, Turkey
serengil@istanbul.edu.tr

Özhan Süleyman
Istanbul University Faculty of Forestry, 
Dept. of Watershed Management
34473, Bahçeköy/Istanbul, Turkey
özhan@istanbul.edu.tr

Received: 19.01.2005