IOP Conference Series: Earth and Environmental Science

PAPER • **OPEN ACCESS**

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To cite this article: H S Suriandjo *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **802** 012035

IOP Conf. Series: Earth and Environmental Science **802** (2021) 012035 doi:10.1088/1755-1315/802/1/012035

Review of the air pollution from the perspective of sound comfort in the coastal space. Case study of the Boboca Monument, Manado City

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Abstract. Continuous exposure to an area with a sound above the threshold level is one of the triggers for noise pollution in public spaces. Public spaces are spaces where people of all ages gather for leisure activities, recreation, etc. The purpose of this study was to find the average dBA value of noise, community perceptions regarding the comfort of sound in coastal public spaces, and the relationship between the dBA value and the existing sound comfort standards. The focus of this research is to contribute to a public space that is free from noise pollution. The study was conducted on the coast of Manado, precisely in the Boboca monument area, using mixed methods through the formula LAeq 10 minutes and Leq daylight to get the standard value of noise. The results found noise numbers in the range 77.4 – 80.2 dBA, this value has exceeded the required standard of 50 dBA, and the results of the perception are also supportive, which is dominant in public perception. It means that coastal public spaces in the Boboca monument area have been exposed to noise pollution.

1. Introduction

The 11th goal in the Sustainable Development Goals (SDGs) is Sustainable Cities and Human Settlements, which focuses on point 11.7 to provide universal access to green spaces and public spaces that are safe, inclusive, and accessible, especially for women and children, the elderly, and people with disabilities [1]. Because what people need in a city is a sense of security, comfort, and tranquillity. When an area does not give a sense of security and comfort to its inhabitants, the area must be immediately anticipated [2]. Comfort can be seen from several points of view, such as thermal comfort, sound comfort, and light comfort. This study focuses on air pollution from the perspective of sound comfort in urban coastal public spaces. The range of human ear ability values in hearing the lowest sound is 0 dB and 140 dB as the highest limit [3].

Table 1. Sound hard level in dB.

Sound Level dB	Examples of Circumstances
140	Hearing upper threshold
130	The airplane takes off
120	Very noisy discotheque
110	Noisy discotheque
100	Noisy factory
90	The train is running
80	Corner crossroads
70	General vacuum cleaners
60	Conversation by shouting
30-50	Normal conversation
20	Quiet village, the wind rustles
0-10	Lower threshold for hearing

In the context of air pollution, unmanaged sounds will become waste that can become waste and become a source of disease for humans. In line with the SDGs' goal of average noise exposure, the Guideline Development Group (GDG) recommends that the level of noise generated by highway traffic is below 53 decibels of dBA and should even be reduced, as road traffic noise when it exceeds the above values will have a detrimental impact on the health of users in green and public spaces, especially for women and children, the elderly and people with disabilities [4]. In the context of sustainability, a calm and comfortable atmosphere is an important next step [5]. There are several main factors and sources of noise pollution, and one of them is highway transportation [6]. Excessive noise exposure has also been found to cause difficulty sleeping and reduce sleep quality, as noise also triggers environmental stress, resulting in impaired physiological health affecting human communication and activity [7]. This is very alarming because every year, there is an increase in noise from 0.5 to 1 dBA [8]. Furthermore, if this condition is allowed, it will disturb the environmental ecosystem and interfere with human health.

Suriandjo and Tondobala (2013) wanted to know the amount of sound comfort value in urban open space areas [9]. The findings showed the comfort response was in the range of 55 to 60 dBA, which turned out to be 20% higher than the required noise standard. The source of noise mainly comes from cars and other motor vehicles. The influence of noise also often interferes with the communication and concentration of users' learning, such as the study conducted by Zikri (2015) wanting to know the level of noise in MTsN 1 Pontianak on the roadside as well as the influence of noise on their learning and communication concentration [10]. It found roadside noise levels of 74.2 dBA, and as many as 96% responded with noise; 89% of respondents said noise from traffic interfered with their concentration and communication. Roadside noise levels were 74.2 dBA, and 96% responded with noise, and 89% of respondents said noise from traffic interfered with their concentration and communication. Another related study conducted by Mutalib, et al. (2018) aimed to evaluate the impact of traffic noise on road corridors to reduce traffic noise [11]. His study was conducted in a residential area located in Taman Mutiara Rini. The study found noise levels above 75 dBA that exceeded the permitted limits recommended by Héroux (2015) and the local Environment Department [4]. A similar study by Kasawneh, et al. (2020) aims to visualize the impact of noise in the form of noise maps through measurements of noise levels at the USM Technical Campus, Nibong Tebal, Penang. The results showed a noise value of 23 points exceeded the maximum allowability limit, 55 dBA, with a maximum noise of 68.3 dBA [12]. The location of this study is an urban coastal public space located on the edge of the highway. Related to the location of the roadside related studies as studied Kamandang, et al. (2020) found that cause of noise in public spaces is traffic because the level of noise caused by traffic, heavy vehicles has an influence of 70.80% on noise levels [13]. It shows that heavy vehicles significantly influence noise pollution than motorcycles and other light vehicles by 66.63% and 30.21%. On the other hand, for every 10% increase in the volume of motorcycles, light vehicles, and heavy vehicles, noise levels also increased by 1,726%, 2,032%, and 1,733%, respectively.

The purpose of this study was to find the average value of noise dBA, public perception related to the comfort of sound in urban coastal public spaces, and the relationship between the value of dBA and the standard of sound comfort. The focus of this research contributes to urban coastal public spaces that are free of noise pollution. Because the public space following the needs of the social level of the community will be able to improve the quality of city space, this study also aims to visualize the value of noise in the form of noise maps to visit urban coastal public spaces and choose a comfortable spot to relax, active, and not be exposed to local noise [14]. The noise map will help see the level of noise pollution in the environment and help understand the activities that contribute to increased sound levels [12].

2. Methodology

This study uses mixed methods. Quantitative Method through the formula approach LAeq 10 minutes and Leq Siang, and Qualitative Method through responsive perception approach of public space users. This research location was carried out in an urban coastal public space, precisely in Boboca Monument, Malalayang District, Manado City. Tugu Boboca area is a space designed and functioned as a recreation room, sightseeing, enjoying the scenery. This location is located on the beach on the coast of Manado city. This area has an area of ± 0.85 ha, a linear form is located along the Trans Sulawesi Arterial Road. See figure 1. According to initial observations, 5 sampling spots at these points become a favorite place to gather users of this public space.

Figure 1. Research location.

Figure 2. Spot measurement (a). spot 1, (b). spot 2, (c). spot 3, (d) spot 3, (e). spot 4, (f). spot 5.

2.1. Sampling method

Samples taken in this study are noise level. Noise level is measured using a sound level meter (SLM) bioblock scientific code 50517 to read values in the range of 30 - 80 dBA. This tool is set on type A to get a measurable sound level in dBA. The meaning is set to this type according to the guidelines in this set of manuals allowing normal sounds and sounds to be heard by the human senses of hearing. Because of the limitations of reading only sample 80 dBA, supported by Sound Level Software installed directly on mobile phones that support up to 100 dBA. Measurement of noise levels can be done in a Simple Way, performed by a minimum of 2 people, one to see the time and record a momentary noise level per five seconds within 10 minutes. The second person will respond by asking for a transient noise level response from the sound level meter (SLM) and the software. Sampling is done by Sugiyono (2011) sample assuming the number of visitors per session time 100 people, at least the sample is determined as many as 30 people [15], where each spot placed 6 respondents. So that the data and responsive obtained will be at the same time. From the values obtained will be obtained 120 data, further, the formula will calculate this value:

$$L_{Aeq,T}\left(10\min ute\right)=10\log_{10}\left[\frac{1}{120}\sum_{i=1}^{120}10^{LpAi/10}\right] \quad (1)$$

Description:
LAeq.T is the level of sound pressure continuous within 10 minutes
LpAi is the average momentary sound pressure level in intervals of 5 seconds

After the LAeq value is obtained next in the calculation of the day noise level by using the formula Leq or LS (specifically during the day) by using the formula:

$$Leq\,(daylight) = LS = 10\,Log\left[\frac{1}{16}\left(T1.10^{LAeg1/10} + ... + ...T4.10^{LAeq4/10}\right)\right] \tag{2}$$

According to the initial observations, spot measurement locations taken on 5 different spots are the dominant place in the select community to take advantage of this public space. The value divided into four minimal measurement times is at 08.00 - .09.00, at 10.00 - 11.00, 15.00 - 16.00, and 17.00 - 18.00. The time is chosen considering 08.00 - 11.00 is a fairly solid time for the community to start an office, school, etc., activities. While the time at 15.00 - 18.00 is chosen considering that community activities are also crowded with returning from work, home school, the community began to relax and choose recreation in coastal public spaces.

The variables analyzed in this study consisted of:

1. Decibel value (dBA) of instantaneous noise per 5 seconds in 10 minutes on 5 (five) different spots.
2. Responsive community users of public spaces.

2.2. Noise mapping

Noise level measurement results as shown in table 1. Processed again using ArcMap 10.8 Software. The values obtained in the analysis use the Inverse Distance Weighted (IDW) Spatial Interpolation Technique approach. Noise values in the 5 existing spots after analysis with the IDW approach will produce the contour of the area that will visually be able to see the spaces exposed to noise. So, it will facilitate the classification of which spaces are comfortable and which spaces are exposed to noise is high enough in this public space.

3. Results and discussion

The measurement results on 5 different urban coastal public spaces were compared to the recommended value of 53 dBA and noise standards prevailing in Indonesia. Recommended noise standard in public open space area of 50 dBA [16]. Seen who recommendations and recommendations of the Minister of Environment of the Republic of Indonesia do not have a significant enough difference. This value is considered quite valid as the basic value of raw reference noise to be used. The measurement results are presented in table 2 and its graph in figure 3 below.

Table 2. The results of dBA measurement on 5 different spots.

Spot	Coordinate	Measurement Time				Average
		08.00 s/d 09.00	10.00 s/d 11.00	15.00 s/d 16.00	17.00 s/d 18.00	
Spot 1	1°27'39.91"N 124°47'1.41"E	67.6	70.6	81.5	82.3	75.5
Spot 2	1°27'40.07"N 124°47'2.64"E	67.1	70.0	81.6	82.8	75.4
Spot 3	1°27'40.24"N 124°47'3.55"E	68.3	71.2	82.0	83.1	76.1
Spot 4	1°27'40.04"N 124°47'4.67"E	68.5	75.1	82.7	83.5	77.4
Spot 5	1°27'40.12"N 124°47'5.70"E	69.7	77.3	84.1	85.1	79.0
	Average	68.2	72.8	82.4	83.4	

IOP Conf. Series: Earth and Environmental Science **802** (2021) 012035 doi:10.1088/1755-1315/802/1/012035

Looking at the measurement results in table 2 above, it is clear that measurements for noise values in Spot 1 to Spot 5 have increased in value from morning to afternoon. For example, spot 1 consecutive noise values from morning to afternoon are in the range of 67.6 dBA, 70.6 dBA, 81.5 dBA, and 82.3 dBA in the afternoon. Similarly, Figure 2 shows a graph of morning measurements from 08.00 to afternoon at 18.00 in Spot 3 to Spot 5 experiencing an increase in noise value.

Responsive levels are also quite different. In the morning conditions at 08.00 – 09.00, the noise value at an average of 68.2 dBA, as many as 70% of respondents answered comfortably. This is quite clear because the condition of the morning passing vehicles has not been too crowded. The condition of 10.00 - 11.00 hours has started to increase the value of noise that has reached an average of 72.8 dBA. As many as 40% of respondents answered uncomfortably, 33% answered uncomfortably, and 27% responded comfortably. The condition of 15.00 - 16.00 increased noise value that has reached an average of 82.4 dBA, along with 67% of respondents answered uncomfortably. The condition of 17.00 - 18.00 noise value increases again and has reached an average of 83.8 dBA. In this condition, as many as 70% of respondents responded with discomfort. One of the noise sources is the number of large vehicles such as trucks and buses passing on arterial roads because this road is a Trans Sulawesi road and the only access to the Regency and City around North Sulawesi connected to Gorontalo Province. Noise conditions, in addition to the factor of heavy traffic, also added with the sound of music from culinary stalls and the sound of public vehicle music that plays the song at will, also compounded by heavy vehicles such as trucks that have changed exhaust from standard to the type that releases noise. This is in line with research conducted by Basir, et al. (2020) found live music has a significant influence on noise levels [17] and Kamandang, et al. (2020) which found one of the causes of noise is large vehicles, and this condition if left will disturb the surrounding community [13].

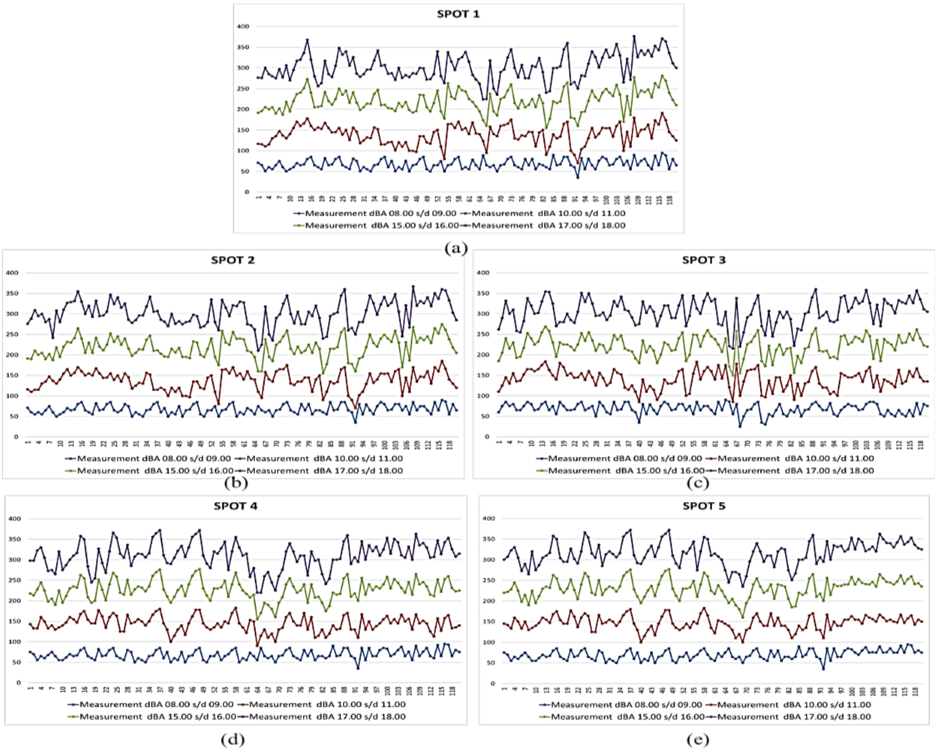

Figure 3. The results of the dBA noise measurement at 5 different spots (a). **s**pot 1, (b). spot 2, (c). spot 3, (d). spot 3, (e). spot 4, (f). spot 5.

The measurement results in table 2, then in the analysis using the Leq formula during the day obtained the results of average noise levels at the research site as presented in table 3 and its graph in figure 4.

Table 3. Leq (daylight) analysis results.

Spot / (LAeq.T)	Measurement Time				Leq / LS (Daylight)
	08.00 s/d 09.00	10.00 s/d 11.00	15.00 s/d 16.00	17.00 s/d 18.00	
Spot 1 (LAeq.T)	46.8	49.8	60.7	61.5	77.4
Spot 2 (LAeq.T))	46.3	49.2	60.8	62.0	77.6
Spot 3 (LAeq.T)	47.5	50.4	61.2	62.3	78.1
Spot 4 (LAeq.T)	47.7	54.3	61.9	62.7	78.7
Spot 5 (LAeq.T)	48.9	56.5	63.3	64.3	80.2

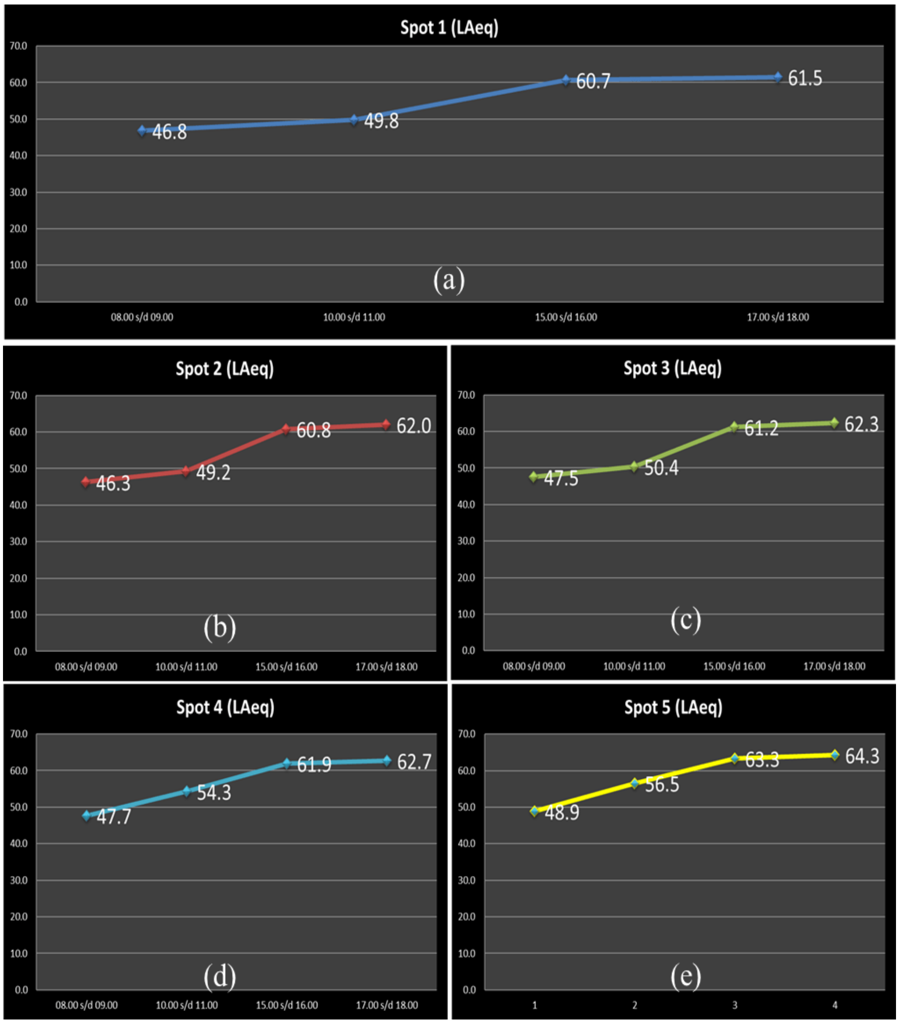

Figure 4. Leq measurement results (a). spot 1, (b). spot 2, (c). spot 3, (d) spot 4, (e). spot 5.

Interestingly also from this study, although the figures obtained in the measurement results are pretty varied, as shown in table 2 before, does not mean that the average number is the standard value of noise prevailing in this region. The value is only the value of the average momentary sound pressure level in intervals of 5 seconds (LpAi). The value becomes a variable to calculate the continuous sound pressure level within 10 minutes with the LAeq formula. Furthermore, in further analysis to find out the level of noise during the day, this quantitative formula will be obtained an average value that is quite different from the average value of the measurement results momentarily. Seen from table 4 and leq spot 1 average value at 77.4 dBA (compared to average measurement 75.5 dBA), Leq Spot 2 at 77.6 dBA (measuring average 75.4), Leq Spot 3 at number 78 .1 dBA (measuring average 76.1 dBA), Leq Spot 4 at 78.7 dBA (measuring average 77.4 dBA), Leq Spot 5 at 80.2 dBA (measuring average 79.0 dBA). Although the values are different the difference is not too big.

Table 4. Leq comparison of average measurement values.

Spot	Coordinate	Average measurement (dBA)	Leq / LS (dBA)
Spot 1	1°27'39.91"N, 124°47'1.41"E	75.5	77.4
Spot 2	1°27'40.07"N, 124°47'2.64"E	75.4	77.6
Spot 3	1°27'40.24"N, 124°47'3.55"E	76.1	78.1
Spot 4	1°27'40.04"N, 124°47'4.67"E	77.4	78.7
Spot 5	1°27'40.12"N, 124°47'5.70"E	79.0	80.2

Noise mapping using IDW can be seen in figure 5. Spots with high noise values are not recommended to linger in this area on Spot 4 and Spot 5 because noise exposure is already at a value of 78.7 – 80.2 dBA. In comparison, the space used for long activities is in spot 1, Spot 2, and Spot 3, although the warning is also in Spot 3 because it is already at a value of 78.1 dBA. It needs to be followed up with physical arrangement through natural barriers such as vegetation to reduce noise around this urban coastal public space area. The increasing volume of vehicles causes an increase in noise. According to the calculation of the number of vehicles passing by is recorded in the range of 452 vehicles per hour. According to previous research, the noise will increase if vehicles exceed 400 vehicles per hour [18]. This increase was also due to the capacity of the road at certain times unable to accommodate the volume of vehicles and cause congestion [19].

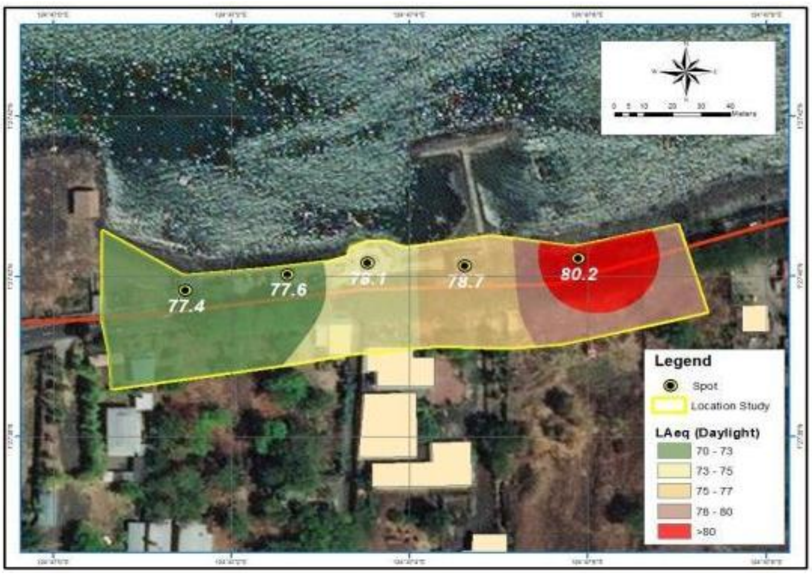

Figure 5. Urban coastal public space noise mapping.

4. Conclusions

In this study, the average value of noise dBA found through LAeq (Siang) analysis is in the range of 77.4 – 80.2 dBA. This value is already above the noise standard required for open space 50 dBA, public perception is similar to the results of this measurement that responds to it less comfortably. Furthermore, the relationship between dBA values of sound comfort is associated negatively in the range of 0.87, meaning that the higher the noise value, the more uncomfortable the public responds to the condition. Furthermore, the visualization of the noise map shows Spot 1 and Spot 2 the noise value is lower than Spot 3 and Spot 4. However, the value is also above the noise standard, so people who visit urban coastal public spaces are advised to choose Spot 1 and Spot 2 for long activities. From some of these findings, it can be concluded that urban coastal public open spaces precisely around the Boboca Monument area have been exposed to air pollution and are less comfortable for community activities.

The advice in this study needs to be followed up with night LAeq measurements so that it will be able to obtain data represented for 24 hours. Also included in the follow-up research is the need to expand the sample and be responsive to the surrounding communities that live in the area. Further research proposals also need to be considered, such as diversion studies and traffic flow arrangements, modifications to heavy vehicles to reduce noise, and vehicle exhaust gas measurements to reduce greenhouse gas emissions, including the impact of air pollution in urban coastal public open spaces. Then for the Manado city government, it is necessary to follow up through programs immediately and physical activities of vegetation planting that serve as a barrier and reduce the noise produced by passing vehicles in this area.

Author Contribution

This article can be completed thanks to the role and contribution of each author through their respective disciplines and expertise, although the dominant Strata 2 / Master of Regional and Urban Planning, but the background of Strata 1 gives its color in this study. Civil engineering background helps to find articles related to transportation and its studies, the background of architects discuss public space and make maps of the area and its studies, and further conclude.

Acknowledgments

The author thanked Bosowa University, where the author continued his Doctoral Program in Regional and City Planning for his support in this research and the University of Nusantara Manado Foundation for the time and opportunity provided and his support he could continue his studies in this Doctoral program.

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