

TEMPERATURE AND RAINFALL IN RELATIONSHIP WITH RING DENSITY AND RING TOTAL NITROGEN OF *Pinus merkusii* IN THE CENTER OF VIETNAM

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Abstract

Tree growth is affected by the environment changes. Mean temperature and annual rainfall at Quang Binh province were used to be representatives of climate. Tree ring density (TRD) and tree ring total nitrogen (TRTN) show the tree growth of pine merkusii in Quang Binh of Vietnam. This paper aimed to study influence of mean temperature and rainfall on TRD and TRTN. Physical method was applied to analyze density based on Archimedes principle and chemical method was used to analyze total nitrogen in the Lab of Institute for Agricultural Environment (IAE) by using the standard of Chonnam National University (CNU) Lab. Tree growth (TRD and TRTN) depends on temperature or rainfall in an linear equation. The results in 12 months of a year showed that August was the most sensitive month relating to environment change and tree growth. The correlation between monthly average temperature and TRD (R square = 0.75^{**}) and TRTN (R square = 0.84^{**}) was positive. The correlation equation between mean temperature and TRD and TRTN was $Y = 0.49X_1 + 11.97X_2 + 26.4$. There was no significant correlation between rainfall and TRD and TRTN. In conclusions, the result was meaningful for interpolating the environment change (mean temperature) from tree ring disk (TRD and TRTN) in a linear equation. $Y = 0.49X_1 + 11.97X_2 - 212337$

Keywords: *Pinus merkusii*, temperature interpolation, tree ring physical and chemical

INTRODUCTION

When determining the ages of a tree and tree growth manually in relationship with climate change, natural phenomenon and process can be restored (Bitvinskas, 1974). By planted climate method, Vuong Van Quynh (1990) showed that tree growth change and breadth of pinus sylvestris in Vaconhezo (Russia) were clearly affected by climate condition. Oberhuber (2002) has established the relationship of temperature and rainfall with change of tree ring of pinus Longaeva, and reported that tree ring widths which are small are caused by low temperature. Tree growth is affected by various environmental factors associated with climate change including changes in air temperature, air precipitation (Giradin *et al.*, 2008).

In the beginning of 20th Century, Duglas conducted to research of many big tree having long age with tree ring and he had conclusion: change of tree ring width show the signature of nature, especial in activated periods of the Sun (Schulman, 1956). In America, scientists had used big amount of tree ring and with modern method to find out the relationship between nature phenomenon change and wood ring change. However, up to now, they did not concern much with tree ring density and tree ring total nitrogen. In this study, TRD and TRTN are two factors reflect most sensitive of tree growth (one for physical quality and one for chemical quality). The width of tree rings (TRW), and the maximum density achieved in their latewood (MXD) are the parameters most often used in dendroclimatology (Hughes 2002). There is a strong

positive relationship between maximum latewood density and tree-ring width data in larch growing at high latitude. This relationship is pronounced for narrow rings (< 0.3–0.7 mm) (Alexander *et al.* 2006). Because of this correlation, a mixture of climatic signals is contained in the variation of each tree-ring parameter. Conditions leading to cool or warm early summer may have little connection with those controlling late summer temperatures (Vaganov and Shashkin 2000). Wolfgang Gindl (2000) confirmed that a cool short growing season produces a narrow, low-density growth ring, whereas more favorable warmer conditions will lead to wider rings with higher latewood densities. Dendro-climatologists make use of this relationship to reconstruct summer temperatures of the pre-instrumental era (Eckstein and Aniol 1981; D'Arrigo *et al.* 1992; Briffa *et al.* 1998). Reduced N uptake under acidic soil conditions results in lower radial growth of Pinus Densiflora via non-stomatal limitation of photosynthesis (Hung Dinh Viet *et al.*, 2012). There are some studies of N uptake from soil, delta N 15 and TRTN in tree ring (Choi *et al.* 2013), but no research about relationship between TRTN and temperature or rainfall.

Correlation, response function and partial correlation analysis indicate that prior year annual (January - December) minimum temperature is most responsible for the higher belt juniper radial growth, while more or less precipitation signal is contained by the tree-ring width chronology at the lower belt and is thus excluded from further analysis (Minhui He

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et al, 2013). Almost study concentrated in tree ring width, so it is clearly in the research results.

Although many researchers have investigated the effects of climatic conditions on tree growth in America, Europe, Canada and Korea (e.g., Kienast et al. 1987; Rolland et al, 1998; Szeicz and MacDonald 1995; Paulsen et al, 2000; Carrer and Urbinati 2004; Choi et al, 2005 - 2007; Jin Hyeob Kwak et al, 2015), but there are few studies reported in Vietnam. In this research, with aim to give out the equation which air temperature and rainfall in a function of ring density and ring Total Nitrogen of *Pinus Merkusii*, one of most widely distributed species in middle of Vietnam, ring samples and soil samples were collected and analyzed for annual tree ring growth. If having this equation, temperature or rainfall may be interpolate in other region in Vietnam from the tree ring when the meteorological stations in Vietnam are limited.

MATERIALS AND METHODS

Site description

Soil samples and tree ring disks were collected in the humid forest at the site located in Quang Son commune (106.42E, 17.75N), Quang Trach district, Quang Binh province in the middle of Vietnam (Fig. 1) in 4 dimensions: South, North, West and East to analyze pH_{KCP}, OC, NH₄⁺, NO₃⁻ and soil particle

All the meteorological data including monthly temperature (average, minimum, and maximum), rainfall were obtained from the Ba Don meteorological monitoring station, located 2 km from the forest site.

At this station, temperature and precipitation data were available from 1961 to 2014 (Fig. 2). The study site is in a typical humid temperate climate zone with a mean annual temperature of 24.5 °C and a mean annual precipitation of 1953 mm during the study period from 1961 to 2014 (Ministry of Agricultural and Rural Development, Vietnam, 2015)

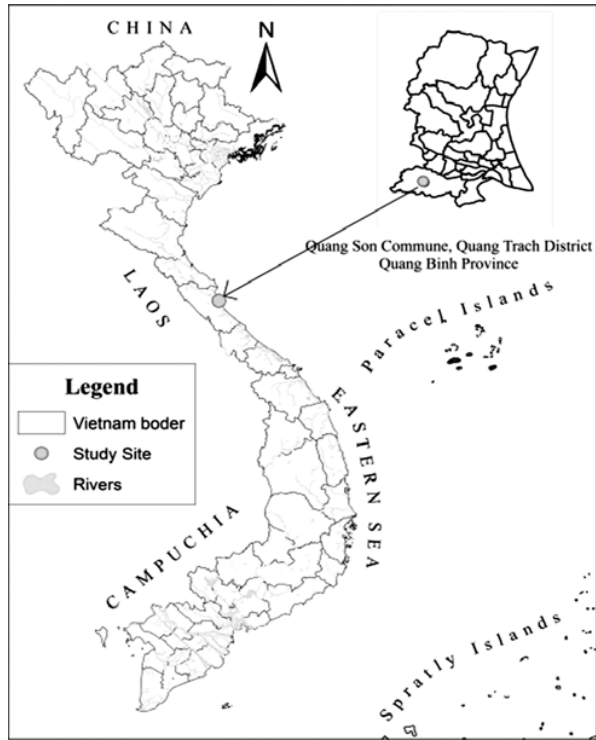


Fig 1. Location of tree ring sample site, meteorological station

Table 1. Pearson correlation coefficients between monthly temperature in 55 years and tree ring width

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Tree ring width	-0.244*	-0.057 ^{ns}	-0.039 ^{ns}	-0.13 ^{ns}	-0.1 ^{ns}	-0.27*	-0.34*	-0.56**	0.33*	-0.07 ^{ns}	-0.19 ^{ns}	-0.04 ^{ns}	-0.39*

Notes: Table 1, 3: ns: non-significant; *, P b 0.05; **, P b 0.01; ***, P b 0.001.

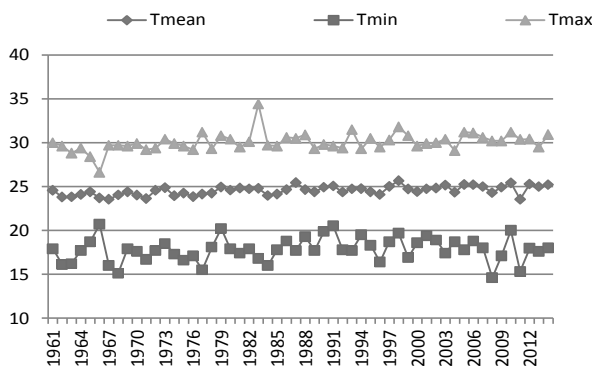


Fig 2. Changes in temperature during the study period: mean (Tmean), minimum (Tmin), and maximum (Tmax) temperatures

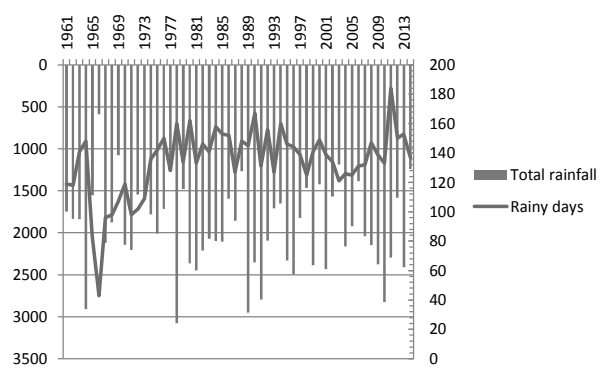


Fig 3. Changes in rainfall and rainy days during the study period

Sampling and measurements

In April 2015, four trees with a range of diameters were selected in a pure *Pinus Merkusii*; Care was taken to select trees that were not shaded by nearby trees to minimize complications associated with tree age and height (Schleser and Jayasekera, 1985; Heaton, 1999). The trees were felled to collect stem disks at breast height (1.3 m)

The disks were polished with a sanding paper and scanned, and ring numbers and ring width were counted using CDendro7 (Cybis Elektronik & Data

AB, Saltsjobden, Sweden). Cross-dating with a master chronology was not necessary because all the rings were clear and no false ring was found. All four disks are similar chronological lengths with around 55 rings.

Measuring tree ring density in a laboratory of the Forestry Institute, Vietnam

Wood specific weight at air dry humidity is calculated by the equation: $P = \frac{m}{V}$

Where as: P: Wood specific weight (g/cm³); m: Wood sample weight (g); V: Wood sample volume (cm³).

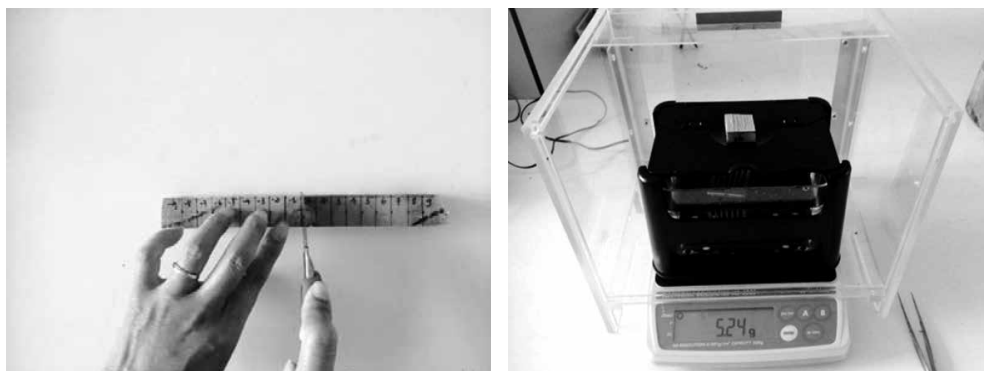


Fig 4. Measuring tree ring density in the laboratory

Sample preparation and chemical analysis

The wood disks were oven-dried at 60 °C to constant weight. The disks were cut into four fan-shaped segments, and wood samples of individual annual rings were collected from all four segments using a dissecting scalpel under a magnifier. The samples were ground to fine powder with a ball mill (MM200, Retsch GmbH, Haan, Germany) and analyzed total Nitrogen by the method 10TCN 451:2001 (Vietnam) and the standard of Chonnam National University Laboratory (Korea).

Statistic analysis

Using SPSS and calculation functions of Excel to

analyze correlations. This method will create correlation equation in a period of over 50 years, then we can interpolate from tree ring characteristic to meteorology data. The monthly average temperature in 12 months from 1961 to 2014 were analyzed correlation with TRD and TRTN. The annual rainfall from 1961 to 2014 were analyzed correlation with TRD and TRTN. After comparing for all 12 months, finally, we chose the August is the most closely month of the year for the data string of meteorology.

RESULTS

Soil characteristic

Table 2. Analyze results in the soil in Quang Binh province

Samples	pH _{KCl}	OC (%)	NH ₄ ⁺ (mg/100g)	NO ₃ ⁻ (mg/100g)	Soil partial (%)			
					Sand	Light sand	Limon	Clay
					>0,2	0,2-0,02	0,02-0,002	<0,002
North	6,92	0,99	7,65	3,84	46,2	20,1	21,9	11,7
Sounth	8,35	0,72	9,93	4,52	48,9	23,8	17,1	10,2
West	7,10	1,06	8,52	3,86	40,9	17,4	27,3	14,4
East	7,36	1,12	3,97	3,19	44,4	28,6	16,9	10,1
Average	7,43	0,97	7,52	3,85	45,10	22,48	20,80	11,60
Std	0,64	0,18	2,54	0,54	3,36	4,85	4,91	2,00

Soil organic carbon in Quang Binh is very low (<1%, Fig. 5) shows poor soil quality and not good for tree growth.

Soil pH>7 (Fig. 5) shows the soil pH here is between neutral and alkali.

NH₄⁺ and NO₃⁻ in the Fig. 5 shows the soil has high easily digestible protein, and good for tree growth.

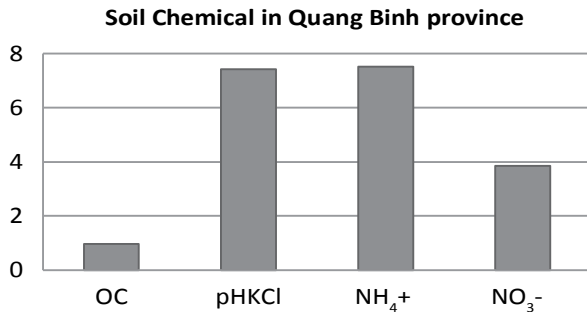


Fig 5. Soil chemical quality in Quang Binh province in average of 4 soil samples in 4 dimensions

Soil Particle in Quang Binh Province

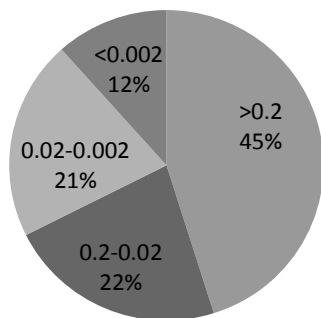


Fig 6. Particle soil in Quang Binh province in average of 4 soil samples in 4 dimensions

Tree ring width (TRW) and basal area increment (BAI)

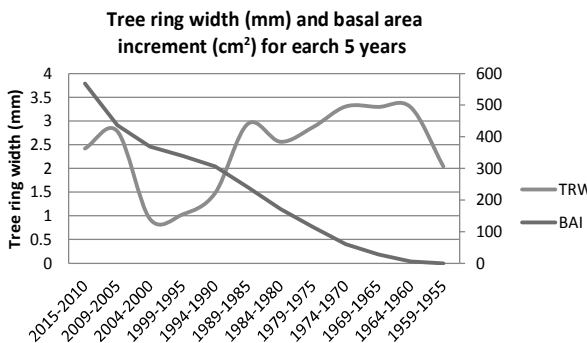


Fig 7. Tree ring width and basal area increment (60 rings in average of four tree disk of Pine Merkusii)

Tree ring density (TRD) and tree ring total nitrogen (TRTN)

The result of tree ring density in Fig. 8 above show that as far the center (1955), the density value as high. The mean density value is 0.734 g/m³, and the highest density value is 0.884 g/m³

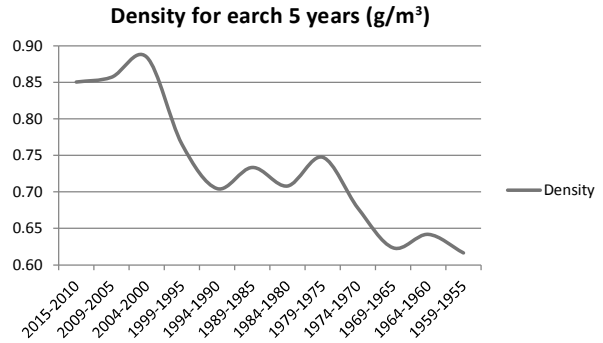


Fig 8. Tree ring density (60 rings in average of four tree disk of Pine Merkusii)

There are similar trend between TRD and TRTN, because the center of the disk is the time having lowest value of TRD and TRTN, and it increases by the time up to 2010.

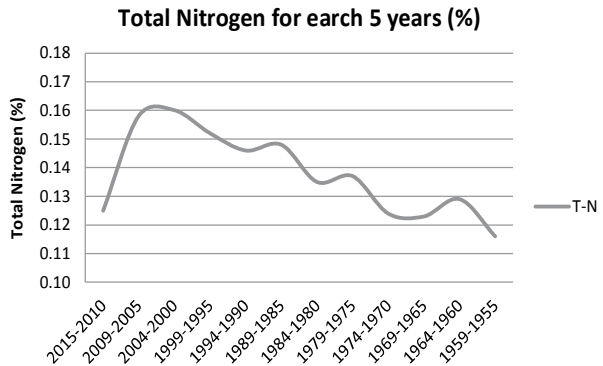


Fig 9. Tree ring total nitrogen (60 rings in average of four tree disk of Pine merkusii)

Statistical results

The result in table 3 shows that no relationship between annual rainy days and TRD and TRTN, and beside the annual total rainfall has week correlation with TRD and TRTN. It can be confirmed rainfall has not affected much tree growth in the center of Vietnam.

But it is significant correlation between average temperature and TRD (0.75^{***}) and TRTN (0.84^{***}). This results show the effect of temperature to tree growth in Quang Binh province.

Table 3. Pearson correlation coefficients between related factors (each 5 year from 1961 to 2015)

Fators	Ring density (g/cm ³)	Ring width (mm)	Basal area increment (mm ²)	Ring Total Nitrogen (%)	Both density and T-N
Avarage temperature (°C)	0.75***	0.61**	0.64**	0.84***	Y = 0.49X1 + 11.97X2 + 26.4 R Square 0.85 ⁺
Annual total rainfall (mm)	0.07 ^{ns}	0.02 ^{ns}	0.09 ^{ns}	0.19 ^{ns}	
Annual rainy days (day)	0.28 ^{ns}	0.12 ^{ns}	0.39 [*]	0.12 ^{ns}	

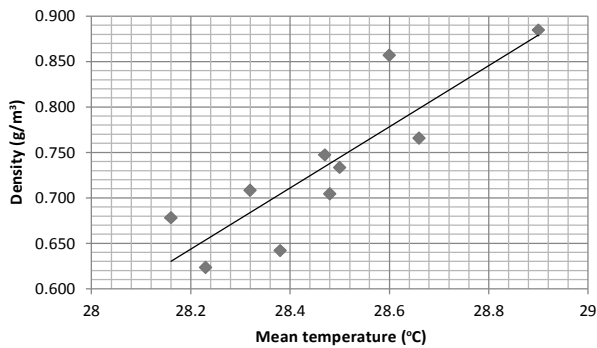


Fig 10. Correlation between tree ring density (TRD) and mean temperature

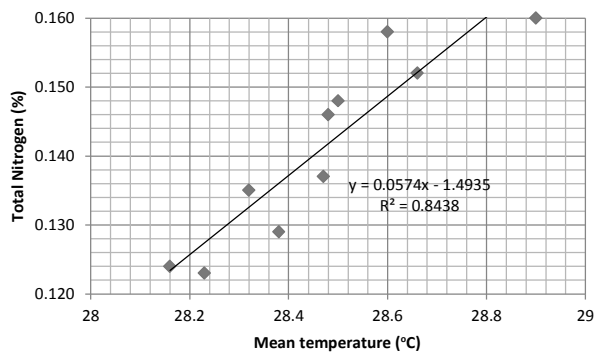


Fig 11. Correlation between tree ring total nitrogen (TRTN) and mean temperature

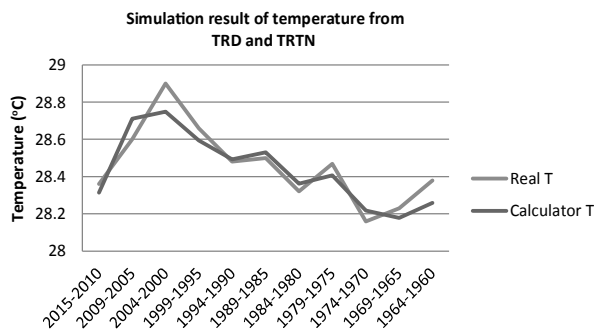


Fig 12. Simulation temperature from tree ring density and tree ring total nitrogen

DISCUSSION

August is highest temperature month in Quang Binh, but it has most sensitive with Pine merkusii

growth, it means in the future when the temperature increase, the interpolation of temperature will more exactly. Koichi Takahashi (2005) showed tree-ring width of *B. ermanii* was negatively correlated with the December and January temperatures and with the January precipitation prior to the growth. It was also confirmed that the tree-ring width was positively correlated with summer temperatures during June-August of the current year. Thus our research found out August is most sensitive month in the center of Vietnam with *Pinus merkusii*.

There is no significant between rainfall and TRD and TRTN (Table. 32), it means the rainfall has affected not much on tree growth with density and nitrogen. There is no argument with the results of Jin Hyeob Kwak et al (2015) that there is no significant correlation between BAI (basal area increment) and precipitation (0.01^{ns} with *P. Densiflora* and 0.23^{ns} with *Q. Variabilis*). Thus, BAI, TRD or TRTN is tree ring factors reflected of tree growth well.

The relationship between average temperature and TRD and TRTN is significant positive correlation with R square over 0.75, P-value<0.01, thus using TRD and TRTN in the history to interpolate the average temperature in Quang Binh in separate, and in other regions in general is very necessary and useful. A positive correlation between the total ring width and the mean temperature of mid-July to August was identified, as was one between the maximum density and the temperature of August- September (Wolfgang Gindl, 2000). Alexander (2006) confirmed TRW is positively correlated with the temperature of four to eight pentads (depending on the region) at the beginning of the growth season, but MXD (maximum latewood density) obtained by the standard technique is correlated with temperature over a much longer period. Jin Hyeob Kwak et al (2015) showed the same result of significant correlation between temperature and BAI (0.46^{**} with *P. Densiflora* and 0.48^{ns} with *Q. Variabilis*). Since then, there is no double that temperature affects directly to tree growth (TRD, TRTN or BAI).

CONCLUSION

If having full data of average temperature monthly, August should be most sensitive month to study about the effects of environment to tree growth in center of Vietnam.

Beside BAI factor (Jin Hyeob Kwak et al, 2015), TRD and TRTN are two new factors to show environment change, especially for temperature, because these two factors show the higher significant correlation (R square and P-value) than BAI.

In general case of Pine Merkusii in Quang Binh province in the period from 1961 to 2015, climate change affects tree growth, while in particular case mean temperature has closed relationship with tree ring density and tree ring total nitrogen, and an equation was found:

$Y = 0.49X_1 + 11.97X_2 + 26.4$, whereas: Y is mean temperature; X1 is tree ring density; X2 is tree ring total nitrogen.

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REFERENCES

- Alexander V. Kirilyanov, Eugene A. Vaganov, Malcolm K. Hughes, 2006. Separating the climatic signal from tree-ring width and maximum latewood density records. *Trees* (2007) 21:37- 44.
- Briffa KR, Osborn TJ, Schweingruber FH, 2004. Large-scale temperature inferences from tree rings: a review. *Global Planet Change* 40:11–26
- Choi, W.J., Chang, S.X., Allen, H.L., Kelting, D.L., Ro, H.M., 2005a. Irrigation and fertilization effects on foliar and soil carbon and nitrogen isotope ratios in a loblolly pine stand. *For. Ecol. Manage.* 213, 90 -101.
- Choi, W.J., Chang, S.X., Bhatti, J.S., 2007. Drainage affects tree growth and C and N dynamics in a minerotrophic peatland. *Ecology* 88, 443 - 453.
- Choi, W.J., Lee, K.H., 2012. A short overview on linking annual tree ring carbon isotopes to historical changes in atmospheric environment. *For. Sci. Technol.* 8, 73–78.
- Choi, W.J., Lee, S.M., Chang, S.X., Ro, H.M., 2005b. Variations of $d^{13}C$ and $d^{15}N$ in *Pinus densiflora* tree-rings and their relationship to environmental changes in eastern Korea. *Water Air Soil Pollut.* 164, 173–187.
- Ghannoum, O., Phillips, N., Sears, M., Logan, B.A., Lewis, J.D., Conroy, J.P., Tissue, D.T., 2010. Photosynthetic responses of two eucalypts to industrial-age changes in atmospheric $[CO_2]$ and temperature. *Plant Cell Environ.* 33, 1671–1681.
- Kwang-Seung Lee, Dinh Viet Hung, Jin-Hyeob Kwak, Sang-Sun Lim, Kye-Han Lee and Woo-Jung Choi, 2011. Tree Ring Ca/Al as an Indicator of Historical Soil Acidification of Densiflora Forest in Southern Korea. *Korean J Environ Agric* (2011) Online ISSN: 2233-4173 Vol. 30, No. 3, pp. 229- 233
- Hung Dinh Viet, Jin-Hyeob Kwak, Kwang-Seung Lee, Sang-Sun Lim, Miwa Matsushima, Scott X. Chang, Kye-Han Lee, Woo-Jung Choi, 2012. Foliar chemistry and tree ring ^{13}C of *Pinus densiflora* in relation to tree growth along a soil pH gradient. *Plant Soil.*
- Jin-Hyeob Kwak, Sang-Sun Lim, Kwang-Seung Lee, Hung Dinh Viet, Miwa Matsushima, Kye-Han Lee, Kangho Jung, Han-Yong Kim, Sang-Mo Lee, Scott X. Chang, Woo-Jung Choi, 2015. Temperature and air pollution affected tree ring $\delta^{13}C$ and water-use efficiency of pine and oak trees under rising CO_2 in a humid temperate forest. *Chemical Geology* 420 (2016) 127 -138
- Koichi Takahashi, Yohei Tokumitsu, Koh Yasue, 2005. Climatic factors affecting the tree-ring width of *Betula ermanii* at the timberline on Mount Norikura, Central Japan. *Ecol Res* (2005) 20: 445-451 DOI 10.1007/s11284-005-0060-y.
- Minhui He, Bao Yang, Nina M. Datsenko, 2013. A six hundred-year annual minimum temperature history for the central Tibetan Plateau derived from tree-ring width series. *Clim Dyn* (2014) 43:641–655. DOI 10.1007/s00382-013-1882-x.
- Wolfgang Gindl, Michael Grabner, Rupert Wimmer, 2000. The influence of temperature on latewood lignin content in treeline Norway spruce compared with maximum density and ring width. *Trees* (2000) 14:409-414 DOI 10.1007/s004680000057.

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RESPONSE OF FRESHWATER SNAIL (*Angulyagra polyzonata*) AS WATER BIOMARKER BY HEAVY METALS (Cd, Cu, Zn, Pb)

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Abstract

Metals toxicity testing of freshwater snail (*Angulyagra polyzonata*) was carried out in laboratory by artificially exposing to metals Cd, Cu, Zn, and Pb less than 48 hours test. The results showed that toxic levels of metals increases in the order: $Zn^{2+} < Pb^{2+} < Cd^{2+} < Cu^{2+}$. In particular, the highest toxicity level was observed by exposing to Cu^{2+} with effect concentrations (EC50) between 0.17 and 0.21 ppm; lethal concentration (LC50) was 2.937 ppm. Other metals (in toxicity order of Cd, Pb, and Zn) in the National Technical Regulation (NTR 08:2008/MONRE) did not affect seriously to snail. The maximum acceptable concentration of the metals for snail in exposure for 48 or 24 hours was Cd: 0.018 - 0.021 ppm; Cu: 0.0008 - 0.0012 ppm; Zn: 0.0071 - 0.082 ppm and Pb: 0.134 - 0.276 ppm.

Keywords: EC, LC, MATC, heavy metals, *Angulyagra polyzonata*, toxicity testing

INTRODUCTION

Currently, along with the increase in the world population, economic development in the developing countries, the living quality is declining due to human activities (exploitation and use of natural resources, discharge of untreated waste physical...). According to the report on the national environments during the last years (2007 - 2015) water quality was severely affected by heavy metals arising from mining activities, industrial coating, metallurgy, transportation, production and processing of heavy metals in the rural regions. The current levels of heavy metals affecting aquatic ecosystems were assessed based on only environmental quality standards (NTR 08: 2008/MONRE for surface water quality). Meanwhile, different levels of metals affecting particular species and ecosystem in general are not the same and should be evaluated for determination of eco-safety concentration value (Capinera, 2008).

Asia freshwater snail (*Angulyagra polyzonata*) was chosen as the test organism because they are available, poor mobility, large size, easy to be observed and has an important role in the freshwater ecosystem. Snail's biological accumulation ability of heavy metals was shown in many previous studies (Dang Kim Chi *et al.*, 2006) because mollusks are benthic species consumed of organic sediments. This study aims to evaluate acute effects of heavy metal concentrations in the water on organism as a basis for determining maximum acceptable toxicant concentration (MATC).

MATERIALS AND METHODS

Materials

1000 ppm original standard solution of the chemicals: $Cd(NO_3)_2$, $Cu(NO_3)_2$, $Zn(NO_3)_2$, $Pb(NO_3)_2$ respectively and individually were added with deionized water.

Freshwater snails (*Angulyagra polyzonata*) were collected from the aquatic system (rivers, canals, ponds...) without waste sources and were used for identification according to invertebrate key (Dang Ngoc Thanh *et al.*, 1980). The individuals were evaluated at adult stage, strong, 10 - 15 mm length, 4 - 6g weight and were stabilized by clean water during 24 hours before the test.

Experiment design

Experiments were arranged based on artificial contamination water of heavy metal concentrations from lowest to highest. Each concentration, there were 5 individuals/500ml water (was repeated 3 times). A blank sample was similarly conducted by deionized water with 100% normally healthy individuals during the test. Based on some scientific data about the toxicity of metals (Rand, 2003; Le Huy Ba, 2006), chosen concentrations were as: Cd^{2+} (0, 0.1, 0.25, 0.5, 0.8, 1, 5, 10, 25, 50, 100 ppm); Pb^{2+} (0, 0.5, 1, 2, 3, 5, 7, 9 ppm); Cu^{2+} (0, 0.005, 0.025, 0.05, 0.01, 0.25, 0.5, 1, 5, 20, 30 ppm); Zn^{2+} (0, 0.1, 0.5, 1, 2, 5, 7, 9, 10 ppm).

The experiment was conducted in a laboratory with natural light, ventilation, average temperature (23 - 25°C), dissolved oxygen DO (3 - 6mg/l), pH = 7.28 - 7.8, from April 2014 to June 2015. Observing the behavior of individuals after 10 minutes, 15 minutes, 30 minutes, 1 hour, 2h, 4h, 8h, 12h, 24h, 36h, and 48h. According to Alonso and Camargo (2010), responses of the organisms were identified as follow:

Normal responses: Moving, muscle contractions.

Affected (abnormal) responses: Immobile, not muscle contraction, closed operculum, death.

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